THE UNSTABLE ISOTOPES OF PLATINUM

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THE UNSTABLE ISOTOPES OF PLATINUM

A Thesis

Presented in Partial Fulfillment of the Requirements

for the Degree of Master of Science

By

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INTRODUCTION

There are a large number of unstable isotopes in the region of iridium, platinum, and gold (fig. 1). A study of the literature on experiments performed shows considerable disagreement and uncertainty in the assignment of mass numbers to periods and radiations that have been measured. It was felt that correctly assigning the unstable isotopes of platinum would be of great assistance in anchoring the activities in this region, and would be of value to future investigators. Therefore a study of the data on the unstable isotopes of platinum that are presently assigned mass numbers 191, 193, 195, 197 and 199 was made to coordinate previous experimental data and to obtain the additional data necessary to definitely establish these isotopes with their correct half-lives and radiation energies.

In order to accomplish this it was attempted to produce these platinum isotopes by methods which had not previously been reported in the literature, or in some cases to make a more complete study of the activities obtained by methods previously used. In cases where the results obtained differed materially from those reported by other investigators, cyclotron bombardments were repeated one or more times to verify the data.

The results obtained in this investigation in some respects agree closely with the results of previous

investigations, while in other cases there are large differences. The experiments performed indicated no changes in the mass numbers previously assigned to the platinum activities found. However up until now the assignment of all five of the above mass numbers has been very questionable, and the very recent work of Cork et al suggested that the previous assignment of the mass number 193 is incorrect (ref. 12). It is believed that in our present investigation that sufficient additional data has been obtained to make the assignments of the mass numbers of platinum isotopes 191 and 193 certain. The data obtained indicated some changes in the energies of the radiations and in the half-lives previously reported, the most important of these changes being the assignment of a 2.0 day half-life to mass number 191 rather than a 3.00 day period. The information given in the nuclear chart of figure no.1, insofar as it relates to the unstable platinum isotopes, is from the data obtained in this investigation rather than the data obtained by previous investigators.

The following sections of this paper give a summary of the experiments made during this investigation, the results obtained, and the conclusions that have been drawn after a study of the experimental results.

NUCLEAR CHART

(PLATINUM REGION)

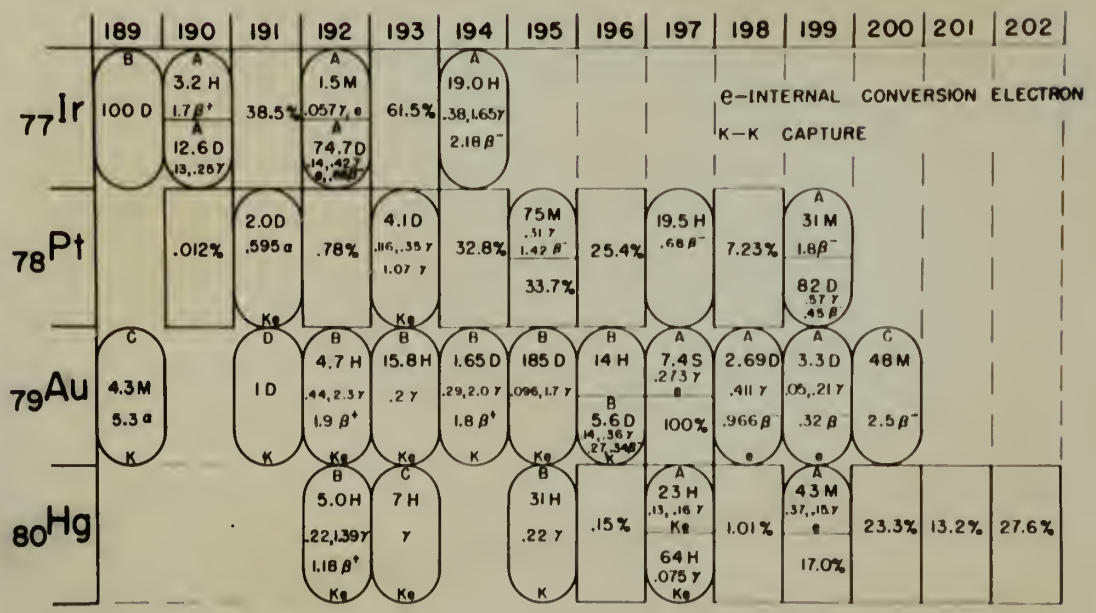

Figure No. 1

EQUIPMENT USED

With the exception of three proton bombardments of iridium foils on the 25 inch cyclotron at Oak Ridge, Tennessee, during the summer of 1951, all bombardments were made on iridium, platinum, gold, osmium and mercury targets on the 34 inch cyclotron at the Ohio State University.

The iridium foils used in the Oak Ridge bombardments were mounted behind a one mil uranium foil. The protons had energies of approximately 19 Mev with a beam intensity of about fifteen microamperes after passing through the uranium. A Tracerlab, Alpha Scintillation Probe, Model P-12, was used to determine possible contamination of the iridium by uranium or fission fragments, or if decay by alpha emission was present.

Bombardments with the Ohio State University Cyclotron were made with protons of 4 to 6 Mev, approximately 10 Mev deuterons, and approximately 20 Mev alpha particles. For 17.5 Mev gamma bombardments and fast neutron bombardments a target holder with an additional slot to hold lithium was used. Slow neutrons were obtained by passing fast neutrons (from a lithium deuteron neutron reaction) through 10 centimeters of paraffin mounted just outside the cyclotron.

Decay and absorption measurements were made with a Wulf electrometer, Geiger Mueller tube TGC-1

(beta tube) incorporating a Tracerlab autoscaler as a scaler (referred to in the remainder of this paper as the beta tube), Geiger Mueller tube T6C-3A (X-ray tube) with a Tracerlab autoscaler (referred to hereafter as the X-ray tube), and a positron counter using a Geiger Mueller tube and a Tracerlab "S4" scaler.

EXPERIMENTS PERFORMED AND RESULTS OBTAINED

A. Proton Bombardments of Iridium

A total of seven bombardments of iridium with protons were made. The first was a one hour bombardment made on a ten mil iridium foil in the Ohio State University Cyclotron. Although activities with half-lives in the vicinity of three days were indicated, the activity was considered too low to make significant measurements.

Three runs were made on the 86 inch cyclotron at Oak Ridge, Tennessee. In each case a ten mil foil was bombarded with protons with energies of approximately 19 Mev. The first was of ten minutes duration and the two following were for twenty minutes each. No chemical separation was made on the first two foils. Decay measurements and lead and aluminum absorption measurements were made. A chemical separation was made on the third foil and decay and absorption measurements made on the platinum fraction.

The decay curves of the two unseparated foils were identical in shape. The breakdown of these decay curves (fig. 2) yielded half-lives of the following periods which are attributed to the isotopes indicated:

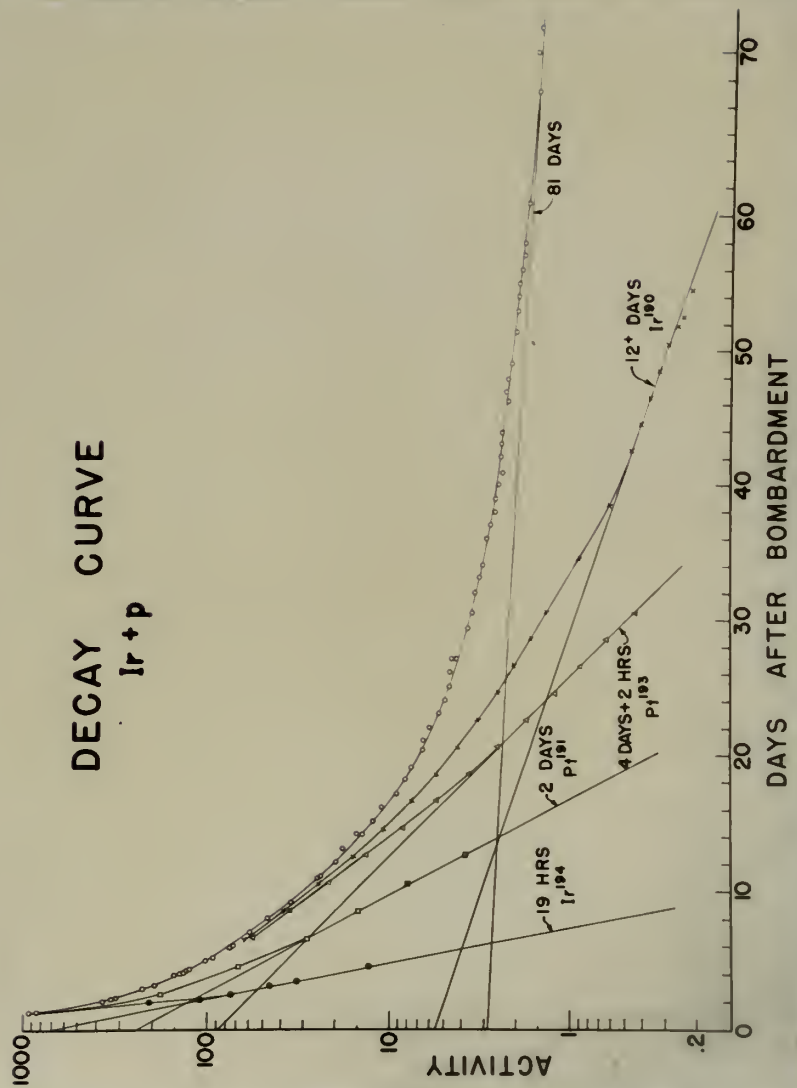
DECAY CURVE
Ir + p
ACTIVITY
1000
100
10
1
.2
DAYS AFTER BOMBARDMENT
0
10
20
30
40
50
60
70
81 DAYS
12+ DAYS
Ir190
2 DAYS
Pt191
4 DAYS+2 HRS
Pt193
19 HRS
Ir194

Figure No. 2

Under 3 hours	Possibly F^{18}
19.0 hours	Ir^{194}
2.0 days	Pt
4.08 days	Pt
12.0 days	Ir^{190}
81.0 days	Possible combination of Ir^{189}, Ir^{192}, and others.

Because of the large number of isotopes and energies of radiations present no consistent or reliable results could be obtained from the lead and aluminum absorption measurements made on these two foils. However during the 81 day period a .68 Mev beta activity, attributable to Ir^{192}, is present. There is also indication of a weaker beta activity of approximately .35 Mev. Measurements are being continued on these two samples.

In the chemical separation the third iridium foil was dissolved in a hot flux of potassium hydroxide and potassium nitrate. The flux was cooled and leached with concentrated hydrochloric acid to which gold and platinum carriers had been added. The gold was then extracted twice with ethyl acetate. A solution of stannous chloride and hydrochloric acid was added to reduce the platinum from the +4 to the +2 state. The platinum was then extracted with ethyl acetate and washed with three normal hydrochloric acid, plated and flamed.

The decay curve of the platinum fraction of this separation broke down to give the half-lives listed below (fig. 3):

2.00 days	Pt^{191}
4.25 days	Pt^{193}
Over 1 year	Unknown

A series of ten aluminum absorption measurements was made during the first 5 days after bombardment, yielding electron end points in aluminum of :

16 mg/cm^2	0.114 Mev
158 mg/cm^2	0.49 Mev
860 mg/cm^2	1.45 Mev

In computing the electron energies, 2 mg/cm^2 was added to the figures listed above to include the thickness of the window of the Geiger Mueller tube on which the measurements were made. A typical absorption measurement is shown in figure 4. The decay of these energies could not be plotted in this case, but these energies can be assigned to be proper half-lives on the basis of data obtained from later bombardments.

A series of four lead absorption measurements was made during the same period yielding energies which decayed at the periods shown below:

.065 or .115 Mev	2.2 days
.35 Mev	4.2 days
.585 Mev	1.88 days

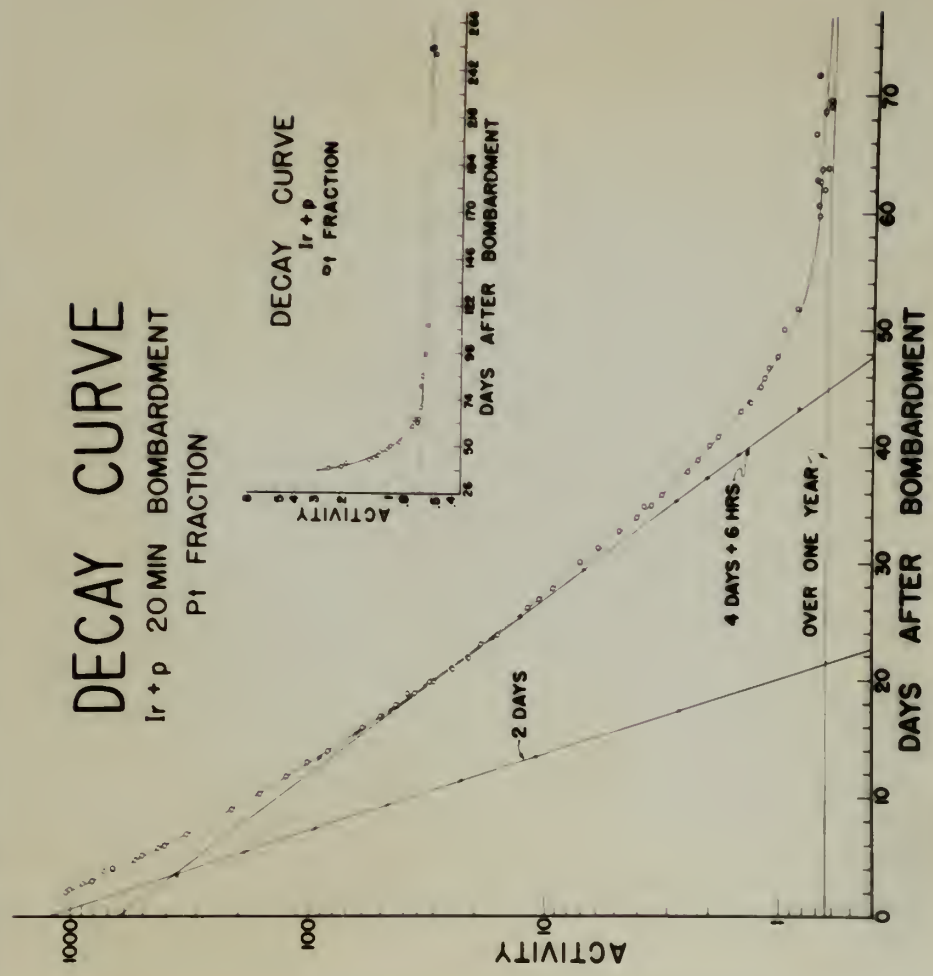
DECAY CURVE
Ir + p 20 MIN BOMBARDMENT
Pt FRACTION
DECAY CURVE
Ir + p
Pt FRACTION
ACTIVITY
DAYS AFTER BOMBARDMENT
2 DAYS
4 DAYS + 6 HRS
OVER ONE YEAR
ACTIVITY
DAYS AFTER BOMBARDMENT

Figure No. 3

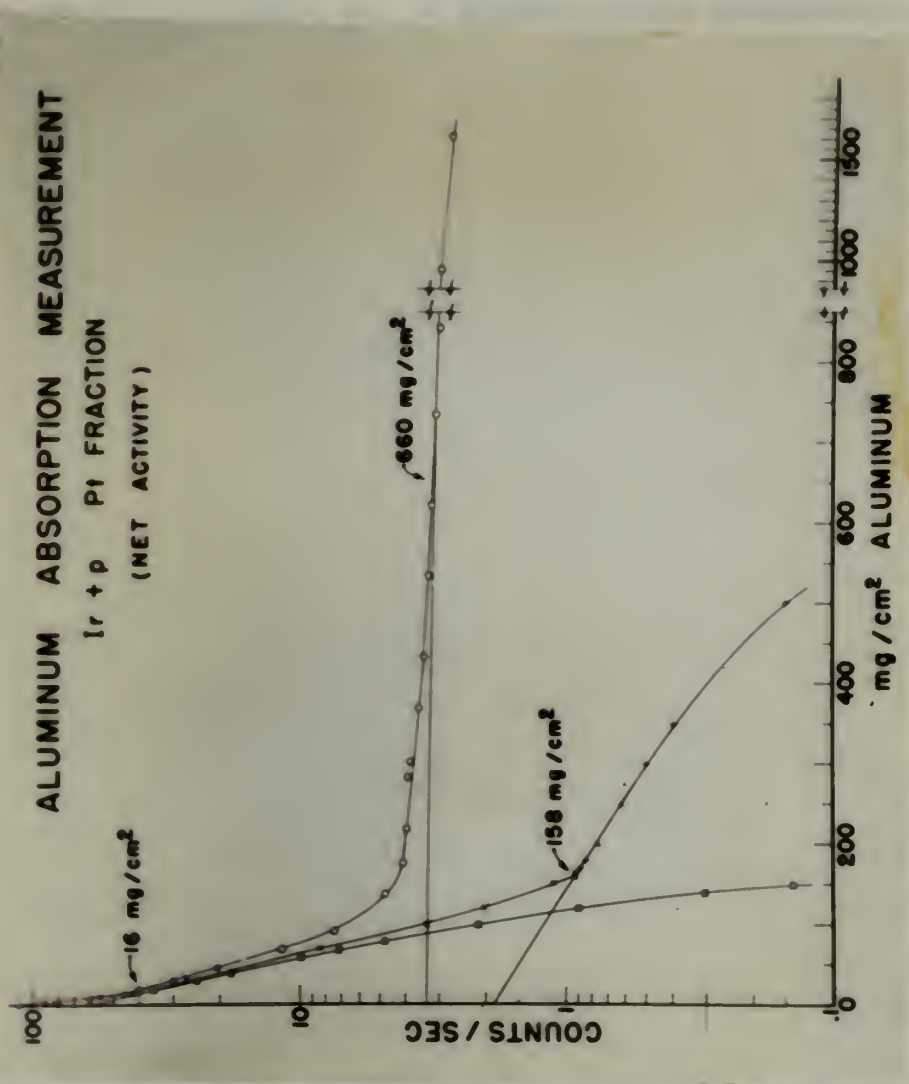
ALUMINUM ABSORPTION MEASUREMENT
Ir + p Pt FRACTION
(NET ACTIVITY)
16 mg/cm²
158 mg/cm²
860 mg/cm²
COUNTS / SEC
100
10
1
.1
0
200
400
600
800
1000
1500
mg / cm² ALUMINUM

Figure No. 4

The first energy listed could be either .065 Mev or .115 Mev. because of the absorption edge for lead between those two energies. Later determinations showed which of the two energies is the correct one. The plot of the decay of the above energies taken from the four lead absorption measurements is shown in figure 5. A typical lead absorption measurement is shown in figure 6.

A check for alpha particles from the two unseparated foils was made with an alpha counter. No alpha particles were detected.

To assist in explaining the periods attributed to iridium, found in the two foils bombarded at Oak Ridge, two 10 mil iridium foils, the second fixed behind and completely shielded by the first were bombarded for one hour with protons on the Ohio State Cyclotron. The protons are not likely to penetrate to the second foil. Activity measurements were taken and showed a ratio of activity of 500 to 30 counts/sec in favor of the forward foil. Decay measurements on the rear foil showed a half-life of 19 hours (attributable to iridium 194) and a shorter period of less than three hours. The presence of the 19 hour period indicates a neutron flux on the rear foil. The 74 day period was not observed due to the low activity. This accounts for the 19 hour period obtained in the two foils bombarded at Oak Ridge.

The other periods may be explained as follows. The 12 day period could be formed by an Ir, p, pn reaction.

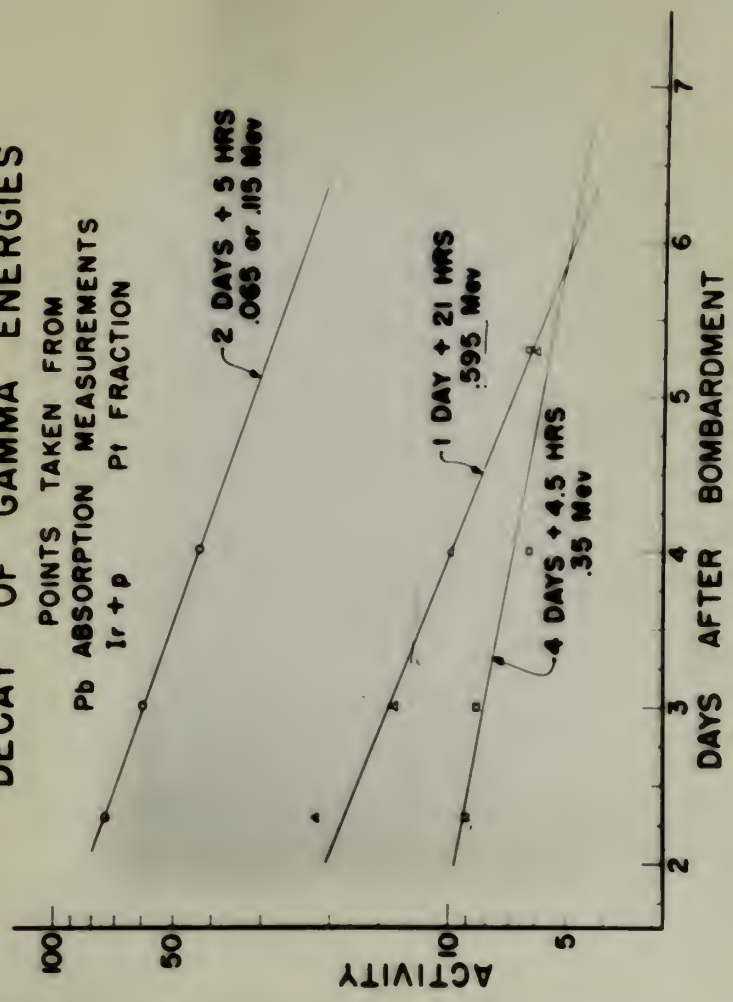
DECAY OF GAMMA ENERGIES
POINTS TAKEN FROM
Pb ABSORPTION MEASUREMENTS
Ir + p Pt FRACTION
2 DAYS + 5 HRS
.065 or .115 Mev
1 DAY + 21 HRS
.595 Mev
4 DAYS + 4.5 HRS
.35 Mev
ACTIVITY
100
50
10
5
2
3
4
5
6
7
DAYS AFTER BOMBARDMENT

Figure No. 5

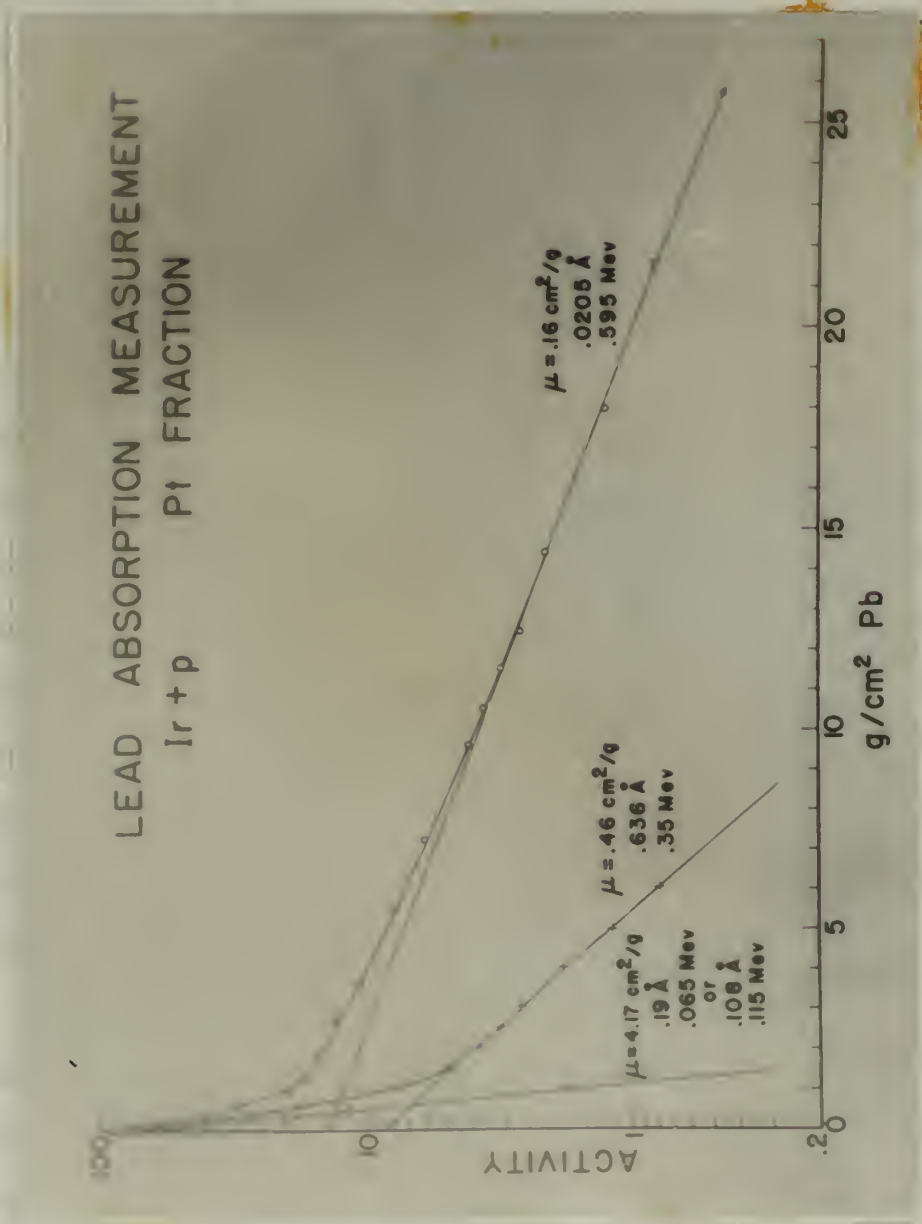
LEAD ABSORPTION MEASUREMENT
Ir + p Pt FRACTION
ACTIVITY
100
10
1
.2
0
5
10
15
20
25
g/cm² Pb
μ = .16 cm²/g
.0208 Å
.595 Mev
μ = .46 cm²/g
.636 Å
.35 Mev
μ = 4.17 cm²/g
.19 Å
.065 Mev
or
.108 Å
.115 Mev

Figure No. 6

The 81 day period that is now being followed could be a combination of the 74 day Ir^{192} formed by neutrons on Ir^{191}, and the 100 day Ir^{189} by a p, p2n reaction, or the Ir^{192} and the period of over one year found in the platinum fraction.

Decay and three aluminum absorption measurements were made on the forward foil. The decay is still being followed. Its shape predicts a period of less than three hours, a 19 hour period, an intermediate period of about 3.5 days, and a longer period that it is expected will be 74 days. The three absorption measurements made during the intermediate period, indicate electron and points at .114 Mev, .49 Mev, and at approximate 1.45 Mev. The .49 Mev electron indicated by all three absorptions decays with a two day period. The decay on the .114 and 1.45 Mev electrons could not be followed as they appear clearly only in the last two absorptions. The 1.45 Mev electron is obliterated by the strong beta of Ir^{194} in the first absorption.

Ammonium Chloroiridate was bombarded with protons. The platinum was separated and the decay of the platinum fraction and of the residue consisting of iridium and the impurities were measured. In both fractions the activity was low. In the platinum fraction only the four day activity was observed with certainty. The decay curve on the iridium and impurities could not be broken down due to the low activity in the longer periods.

However, a comparison of the two decay curves indicated that the separation was successful as the 4 day platinum activity did not appear in the residue. The 4.08 day period in the platinum fraction was followed for five half-lives.

Hilger iridium powder was bombarded for six hours by protons, and separated chemically. The impurities in the iridium were Magnesium, Copper, Calcium, Rhodium, and possibly Platinum. Special care was taken in forming the platinum fraction to exclude these elements, and their products due to a proton bombardment. With this exception the chemistry was the same as that performed on iridium foil from which platinum was separated at Oak Ridge.

The decay of a small portion of the iridium powder was followed in the unseparated form and the decay curve appears to consist of periods of less than three hours, 19 hours, a two and four day period and a longer period that is still being followed. The greater portion of the activity is from the four day period.

The decay of the platinum fraction of this sample yielded periods of 2.04 days and 4.12 days (fig.7). The four day period was followed for eight half-lives. Two aluminum absorption measurements establish electron end points at 16 mg/cm^2, 158 mg/cm^2 and at approximately 800 mg/cm^2. An absorption with polystyrene compared with aluminum shows the existance of weak electromagnetic activity.

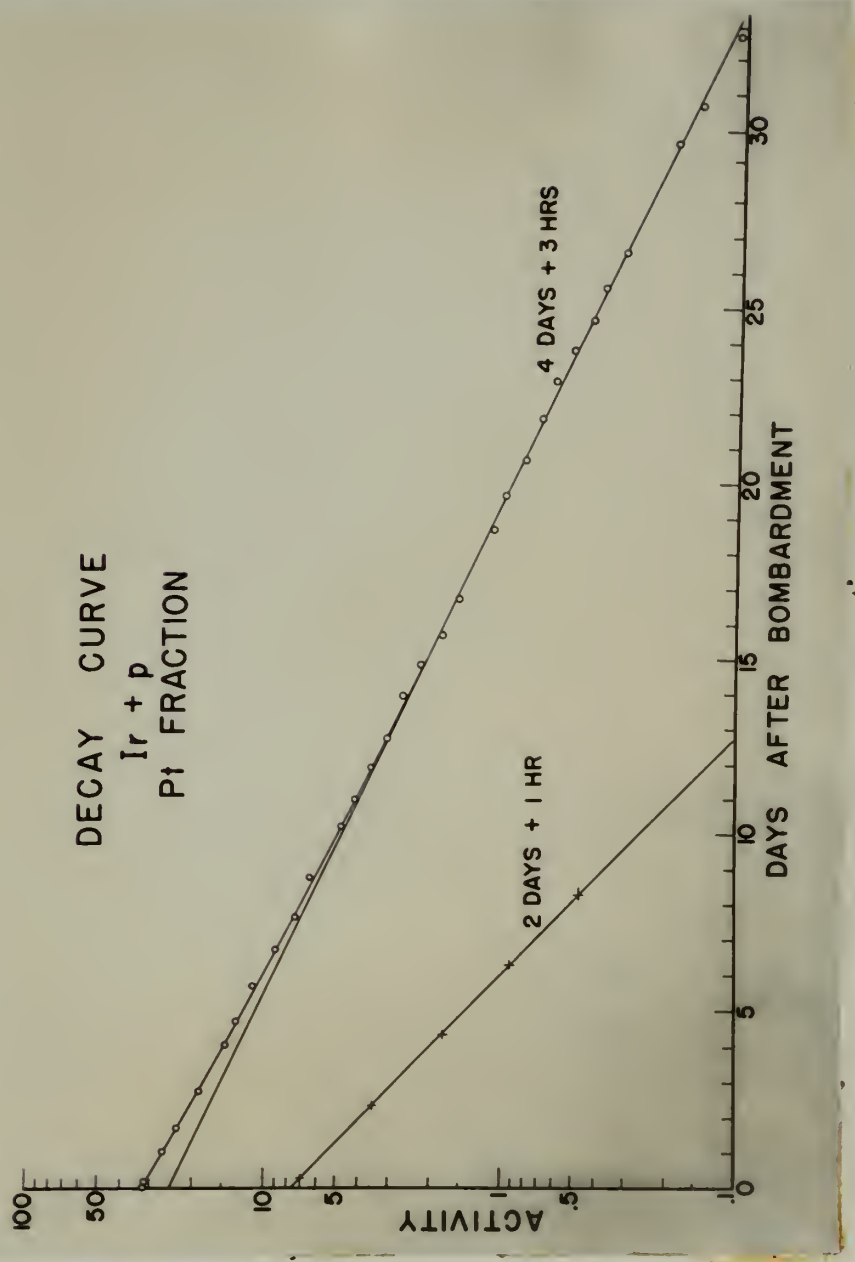
DECAY CURVE
Ir + p
Pt FRACTION
4 DAYS + 3 HRS
2 DAYS + 1 HR
ACTIVITY
DAYS AFTER BOMBARDMENT
100
50
10
5
1
.5
.1
0
5
10
15
20
25
30

Figure No. 7

This fraction was followed in a counter sensitive to beta, x-rays and gamma radiation (x-ray tube), and in another counter that has about the same sensitivity to electrons, but with very little sensitivity to x-ray and gamma radiation (beta tube). The decay curve from the tube sensitive primarily to beta particles starts out in a longer period than the curve from the x-ray tube. This indicates that a greater portion of the electromagnetic activity is due to the two day period.

The decay of the iridium and impurities, the remaining fraction, indicates a long period of approximately 74 days, a period of 19 hours, and a short period of less than three hours. There is no evidence of a two day or four day period. The sample is still being followed.

To determine the nature and rate of decay of the weak electromagnetic radiation .49 and 1.45 Mev electrons, a 10 hour proton bombardment of iridium was made. A chemical separation was made by the method described previously. The decay of the platinum fraction is being followed on both the x-ray and beta counters, and through a 17.15 mg/cm^2 aluminum absorber on the beta tube. The direct decay curve on the beta tube starts with a period of about 3.9 days. The decay through the 17.15 mg/cm^2 aluminum starts at about 2.8 days. The difference between the two curves plots as a straight line at a

4.08 day period. This again verifies that the .114 Mev electron decays with the four day period. The ratio of the initial activity between the decay curve to that of the curve with the absorber was five to one, showing that the greater part of the activity is due to the soft electron with the four day period.

A series of aluminum absorption measurements, of which figure 8 is typical, was made. Consistant results were obtained. Electron end points were determined at .114, .49, and 1.45 Mev. The decay of these activities was followed by breakdown of the absorption measurements (fig.9). The .114 decays at a four day rate and the .49 and 1.45 end points at a two day rate.

A series of aluminum absorptions through 661.5 mg/cm^2 of polystyrene (the polystyrene cuts out all electrons, but decreases the x-ray activity very little) was made over a period of seven days. They show half thicknesses for electromagnetic radiations of 1.25 A° and .85 A°. Figure 10 is one of these absorptions.

The 1.25 A° (9.9 Kev) is an intermediate wave length for the L x-rays of iridium. This energy decayed at an intermediate rate of about three days and thus must be present with both the two day and four day isotopes. The .85 A° (14.3 Kev) decays with the two day period.

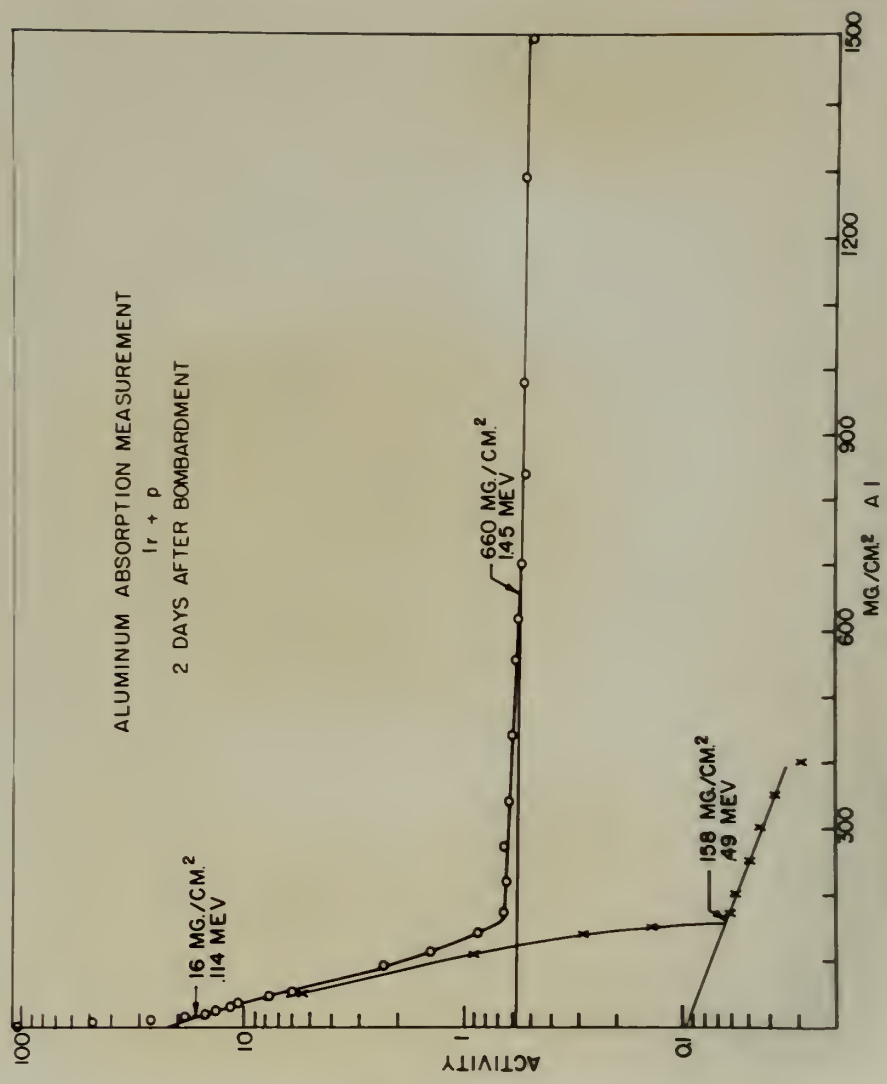
ALUMINUM ABSORPTION MEASUREMENT
Ir + p
2 DAYS AFTER BOMBARDMENT
16 MG./CM.²
.114 MEV
660 MG./CM.²
1.45 MEV
158 MG./CM.²
.49 MEV
ACTIVITY
100
10
1
0.1
300
600
900
1200
1500
MG./CM.² Al

Figure No. 8

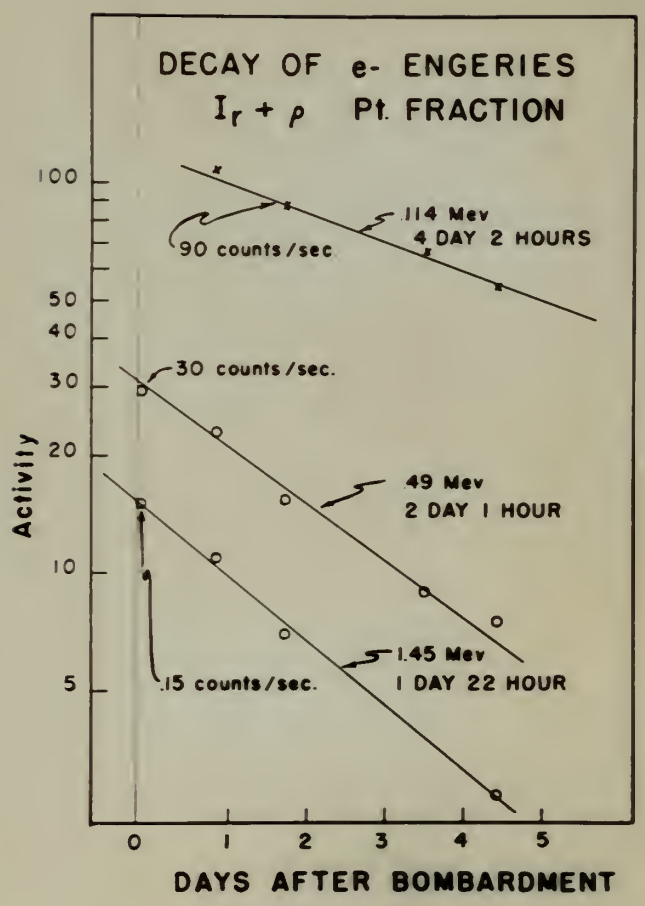
DECAY OF e- ENGERIES
$I_r + \rho$ Pt. FRACTION
100
50
40
30
20
10
5
Activity
90 counts/sec
.114 Mev
4 DAY 2 HOURS
30 counts/sec.
.49 Mev
2 DAY 1 HOUR
.15 counts/sec.
1.45 Mev
1 DAY 22 HOUR
0
1
2
3
4
5
DAYS AFTER BOMBARDMENT

Figure No. 9

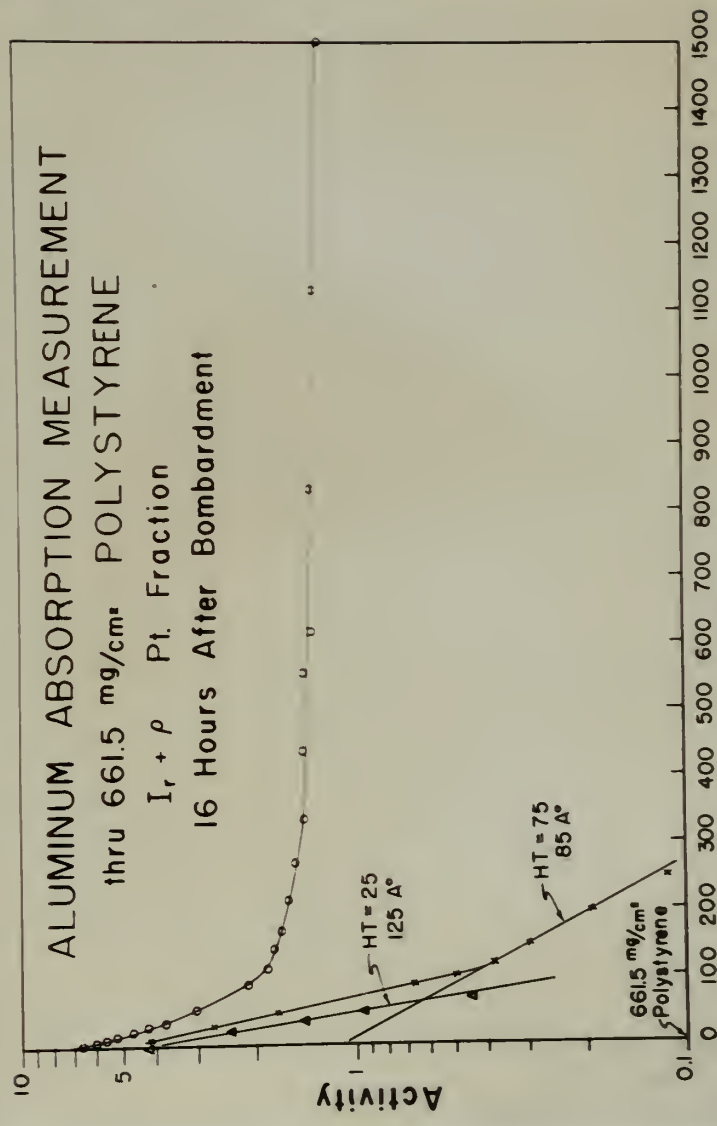
ALUMINUM ABSORPTION MEASUREMENT
thru 661.5 mg/cm² POLYSTYRENE
$I_r + \rho$ Pt. Fraction
16 Hours After Bombardment
HT = 25
125 A°
HT = 75
85 A°
661.5 mg/cm²
Polystyrene
Activity
10
5
1
0.1
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
mg/cm² Al

Figure No. 10

K x-rays were determined by silver and copper absorption measurements through 651.5 mg/cm^2 polystyrene (fig.11). A series of five copper absorptions was made over a period of seven days. The decay of the K x-ray activity plots at about 3.4 days, indicating that it is present in both the two and four day period.

B. Gamma bombardments of platinum.

Three gamma bombardments were made on platinum. Lithium was bombarded with protons to obtain 17.5 Mev gamma radiation. As the gamma radiation is penetrating, in each case numerous platinum foils were used as a target so that simultaneous readings could be taken on different instruments. In one of the bombardments a rod of Hilger platinum was used to establish that the activities found in the platinum foils were not due to impurities. The test was positive as the Hilger foil decays with periods of 30 minutes, 75 minutes, 20.5 hours and 4.083 days, which are in general the periods obtained in the foils. Due to geometry of the rod, the small solid angle it subtended, its activity was considerably lower than that of any of the foils, and therefore the measurements from the foils are used for accuracy. Hilger platinum in the form of a foil was not available.

The 31 minute period has been assigned to Pt^{199} an A isotope. It indicates that a neutron flux was also present in these bombardments, and therefore if

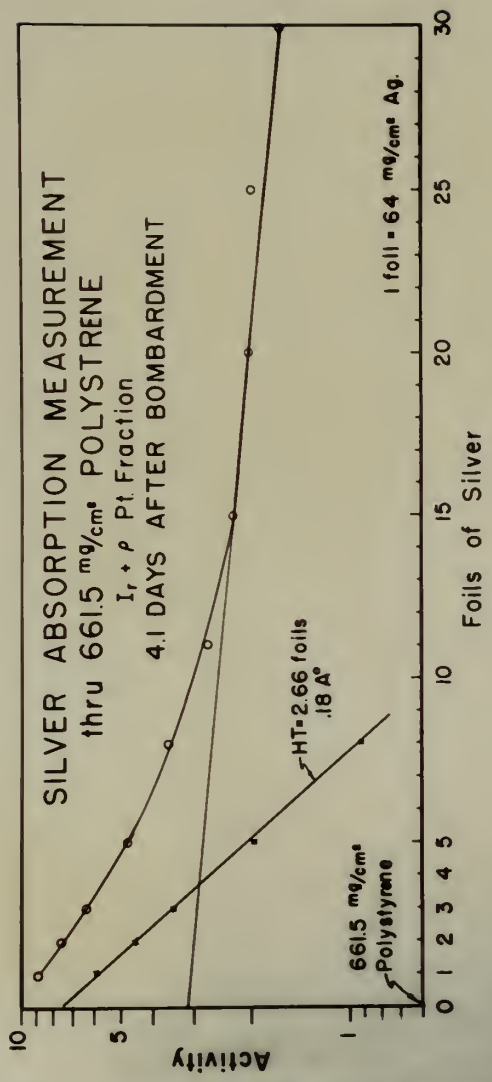
SILVER ABSORPTION MEASUREMENT
thru 661.5 mg/cm² POLYSTRENE
$I_r + \rho$ Pt. Fraction
4.1 DAYS AFTER BOMBARDMENT
1 foil = 64 mg/cm² Ag.
HT=2.66 foils
.18 A°
661.5 mg/cm²
Polystyrene
Activity
10
5
1
0 1 2 3 4 5 10 15 20 25 30
Foils of Silver

Figure No. 11

a high enough activity could be attained, the 82 day period believed to be isomeric with the 31 minute period should also be detectable.

The first platinum plus gamma run was of six hours duration. Three targets were arranged under the water jacket of the target holder. Their decay was followed on four separate instruments, and aluminum absorption measurements were made on the beta tube and the x-ray tube, which were two of these instruments. The electrometer, and the positron counter were the other two instruments used to measure decay.

The decay curves all established consistant results. On the positron counter the decay of electrons indicated a short period of about 75 minutes and a 19 hour period. A magnetic field strong enough to eliminate soft electrons was used. No positrons were discernable. On the electrometer decay was measured directly and through .25 inches of aluminum. The direct decay curve gave periods of 75 minutes, 19 hours, and 4.083 days. The decay curve through 0.25 inches aluminum showed that only the 75 minute and 4.08 day isotope emitted an appreciable amount of electromagnetic radiation. There was very little indication of the 19 hour period in this curve. On the x-ray tube the analyzed decay curve shows that 75 minute, 20.5 hours and 4.083 day half-lives are present.

A decay curve from this same tube through 439 mg/cm^2 aluminum, again indicated that the 19 hour isotope emits comparatively little electromagnetic radiation. On the beta tube the same periods were attained.

Aluminum absorption measurements on both counters indicated electron end points at 16 mg/cm^2, 250 mg/cm^2, and about 630 mg/cm^2 with the exception that the 630 end point appeared only in the first absorption taken on the Beta tube which was within the first two hours after the bombardment. On the x-ray tube four aluminum absorptions were made, on the last absorption, 158 hours after the bombardment, breakdown of the absorption curve indicated an intermediate end point at approximately 90 mg/cm^2.

More activity was needed to obtain more accurate measurements and to associate the different energy electrons emitted with their proper half-lives. A one hour bombardment with two foils directly beneath the lithium target was tried. This resulted in more activity.

Decay and absorption measurements were made on the x-ray tube and on the beta tube. On the x-ray tube, periods of 70 minutes, 20.8 hours and 4.08 days were obtained (fig. 12). The four day period was followed for eight half-lives. Also on this tube the decay through 271 mg/cm^2 aluminum was followed and

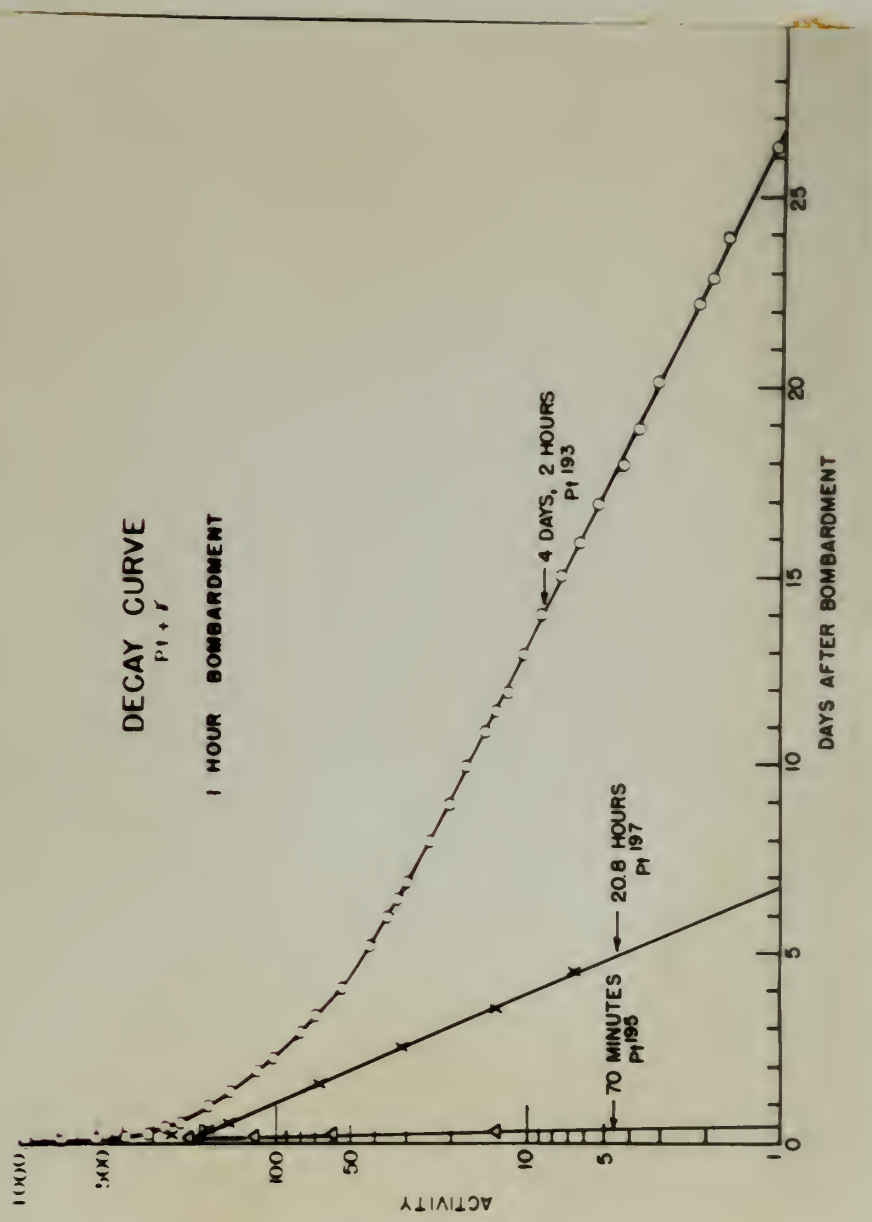
DECAY CURVE
Pt + r
1 HOUR BOMBARDMENT
4 DAYS, 2 HOURS
Pt 193
20.8 HOURS
Pt 197
70 MINUTES
Pt195
ACTIVITY
1000
500
100
50
10
5
1
0
5
10
15
20
25
DAYS AFTER BOMBARDMENT

Figure No. 12

confirmed the previous result that the 20 hour period was not a gamma emitter. On the beta tube periods of 30 minutes, 70 minutes, 19.5 hours and 4.083 hours were measured.

Aluminum absorption measurements were made on both tubes, with results as tabulated below:

	Hours after Bombardment	Electron end points in mg/cm^2 Al
X-Ray Tube	1	630
	4	~630
	27	250 ~16
	52	250 16 ~90
	152	250 ~90 (fig.13) 16
Beta tube	1.5	627 (fig.14)
	5	250 ~16
	27	250 ~16
	64	250 16
	146	250 90 16

The energies including correction for window are:

630 mg/cm^2-1.43 Mev, 250 mg/cm^2-.685 Mev., 16 mg/cm^2-0.114 Mev.

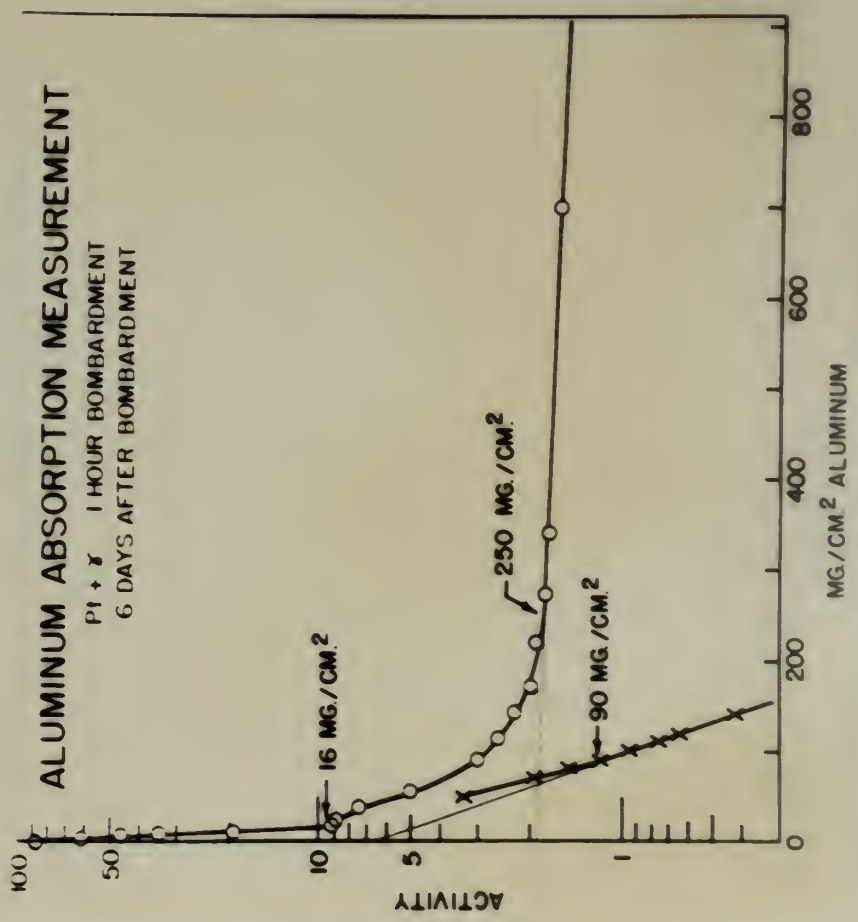
ALUMINUM ABSORPTION MEASUREMENT
Pi + γ 1 HOUR BOMBARDMENT
6 DAYS AFTER BOMBARDMENT
16 MG./CM.2
250 MG./CM.2
90 MG./CM.2
ACTIVITY
100
50
10
5
1
0
200
400
600
800
MG./CM.2 ALUMINUM

Figure No. 13

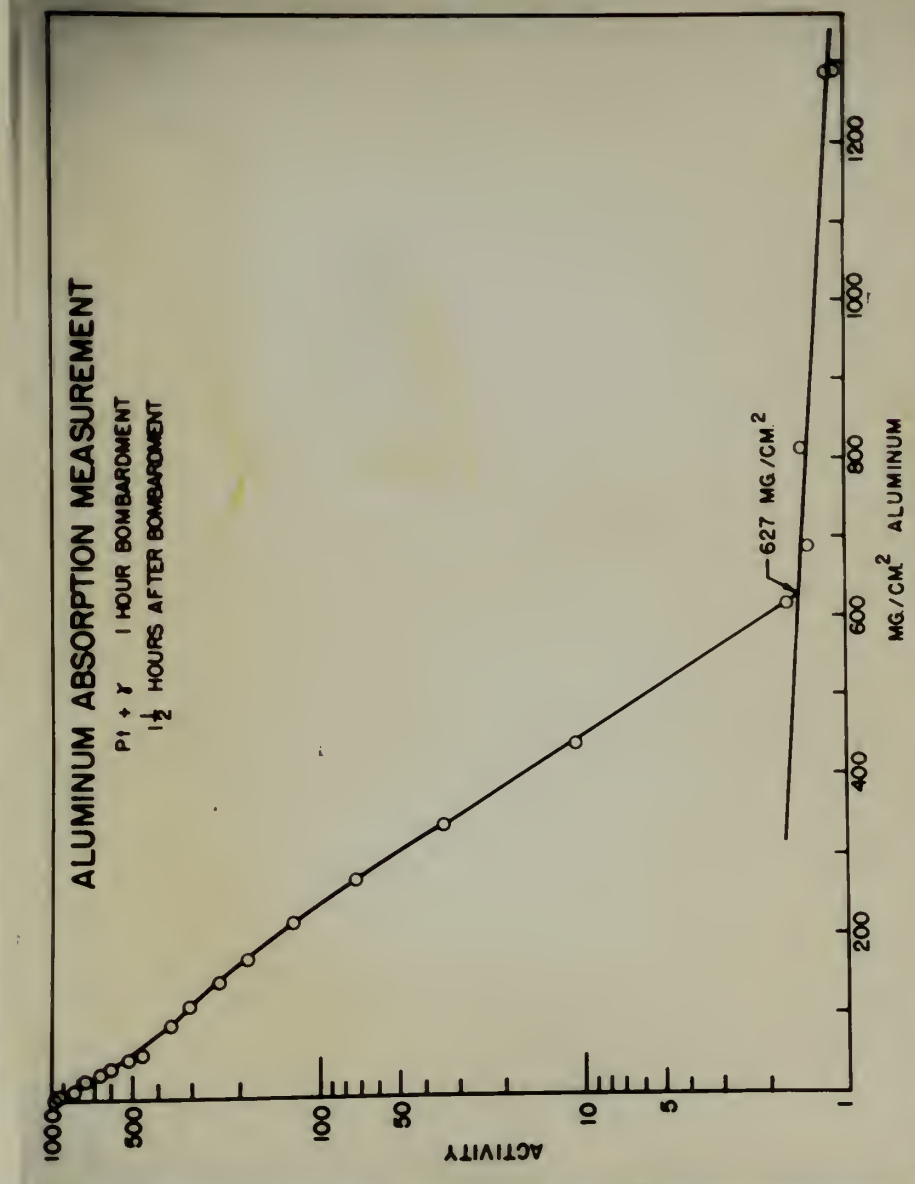
ALUMINUM ABSORPTION MEASUREMENT
Pt + γ 1 HOUR BOMBARDMENT
1½ HOURS AFTER BOMBARDMENT
627 MG/CM²
ACTIVITY
1000
500
100
50
10
5
1
200
400
600
800
1000
1200
MG./CM² ALUMINUM

Figure No. 14

As weak electromagnetic activity was apparent in the absorptions on the x-ray tube, the decay of the electrons at the measured energies could not be plotted. On the beta tube the decay of .685 Mev and .114 Mev electron could be plotted (fig.15), which definitely associate the .685 Mev with the 20 hour isotope and the 0.114 Mev with four day isotope. The 1.42 Mev electron is associated with either the 30 minute or 70 minute period. Examination of the decay curve on the beta tube places it more probably with the 70 minute period.

Another six hour platinum gamma bombardment was made. On this run four platinum targets were used. The Hilger iridium rod previously described and a platinum foil enclosed in a cadmium box were fastened beneath the water jacket. A foil was placed beneath the lithium target, and a platinum target holder was used to contain the lithium target. Decay measurements were made on all four. Aluminum absorption measurements were made on the foil directly under the target and on the platinum target holder. Lead absorptions were made on the target holder.

The decay of the Hilger platinum rod was discussed previously.

The periods in the decay curve of the cadmium wrapped foil were the same as those previously attained.

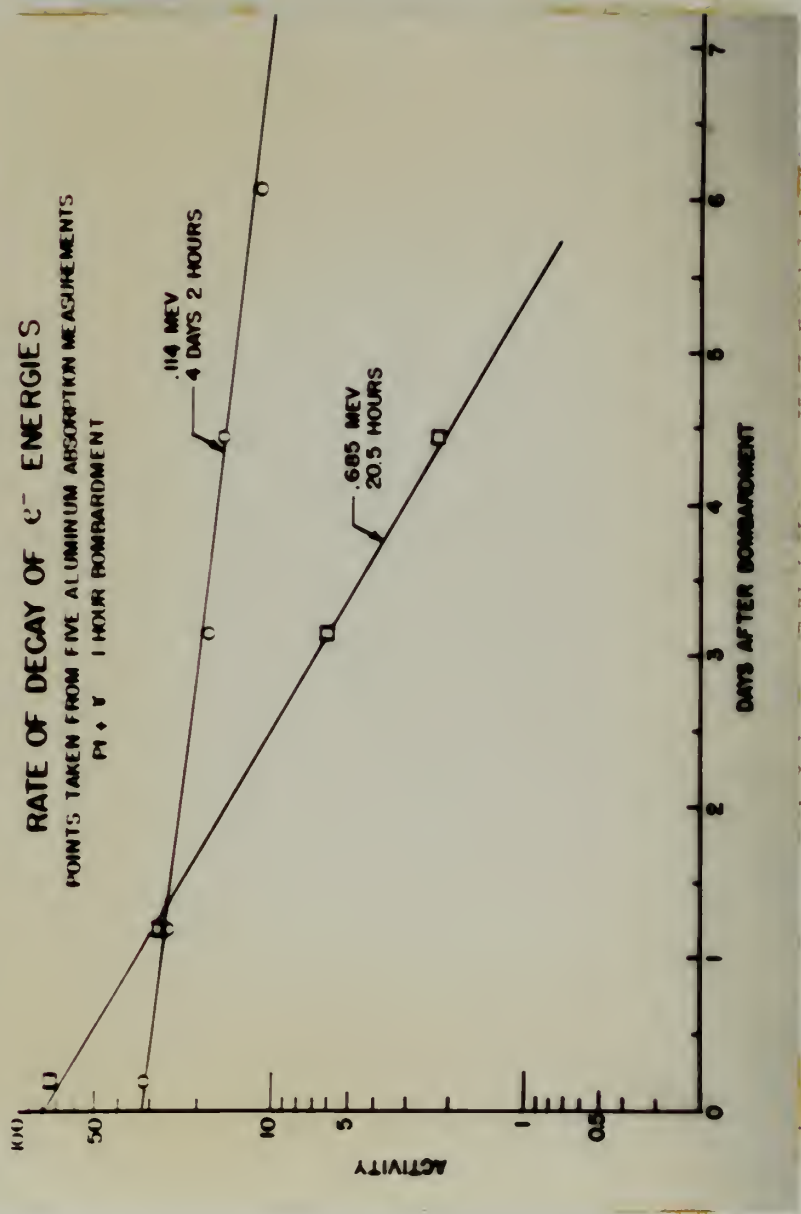
RATE OF DECAY OF β⁻ ENERGIES
POINTS TAKEN FROM FIVE ALUMINUM ABSORPTION MEASUREMENTS
Pt + γ 1 HOUR BOMBARDMENT
.114 MEV
4 DAYS 2 HOURS
.685 MEV
20.5 HOURS
ACTIVITY
100
50
10
5
1
0.5
0
1
2
3
4
5
6
7
DAYS AFTER BOMBARDMENT

Figure No. 15

The 30 minute period was still present. This indicated that the 30 minute period could be formed from fast neutrons.

The platinum foil directly beneath the target was useful. In addition to the periods reported previously, a two day period was apparent at a very low activity. It was evidently formed from platinum 192 by a gamma neutron reaction. Platinum 192 comprises only about 0.78% of the natural stable platinum, therefore the very low activity of the platinum 192 was to be expected. The 4.083 day period was followed for eleven half-lives and therefore should be accurate (fig.16). There was no indication of a longer period in this sample.

Two aluminum absorption measurements were completed on this foil on the beta tube during the first five hours after bombardment. The electron end point previously associated with the short period was measured at 527 mg/cm^2 giving a value of 1.42 Mev. As the activity of the 30 minute period at the time of this second absorption was less than 0.01 counts per second, the 1.42 Mev electron can be definitely associated with the 75 minute period (fig.17). Other absorptions verified the 16 mg/cm^2 and 250 mg/cm^2 end points as being with the four day and the 20 hour periods respectively. Aluminum absorption measurements made 9 days and 9.7 days after bombardment show an electron end point at 90-110 mg/cm^2.

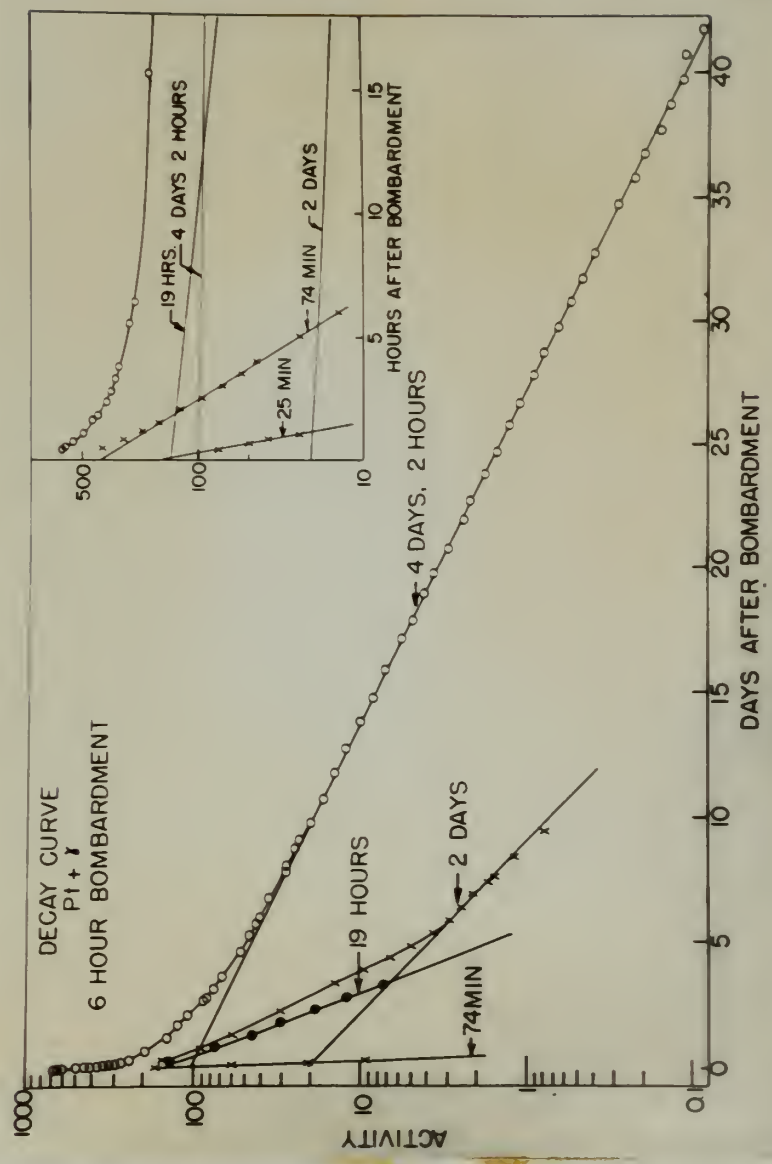
DECAY CURVE
Pt + γ
6 HOUR BOMBARDMENT
ACTIVITY
1000
100
10
1
0
5
10
15
20
25
30
35
40
DAYS AFTER BOMBARDMENT
74MIN
19 HOURS
2 DAYS
4 DAYS, 2 HOURS
500
100
10
5
10
15
HOURS AFTER BOMBARDMENT
25 MIN
74 MIN
2 DAYS
19 HRS
4 DAYS 2 HOURS

Figure No. 16

An aluminum absorption on this same sample made on the x-ray tube 10 days after the bombardment compared with an absorption made with polystyrene directly after shows the presence of X or gamma radiation (fig.18).

Due to the size of the platinum target holder and the large solid angle it subtended, considerably more activity was obtained than with the other samples. On this sample the decay is being measured directly on the x-ray tube. It is also being measured through 170 and 271 mg/cm^2 aluminum absorbers, and through 500 and 2,900 mg/cm^2 lead absorbers. In addition to this a series of aluminum and lead absorption measurements are being made. It is believed that when the various decay curves mentioned above reach base lines and can be broken down that analysis of the various absorption measurements and decay curves together will give a considerable amount of information.

It was found on analyzing the aluminum absorption measurements on the x-ray tube taken during the first 30 days after bombardment that they are far too complex to accurately plot the decay of individual energies. However, eliminating a few of these energies from the composit absorption curves will assist in an analysis. Therefore plots are being made of the values shown in figure 19, which is a typical aluminum absorption made on this sample.

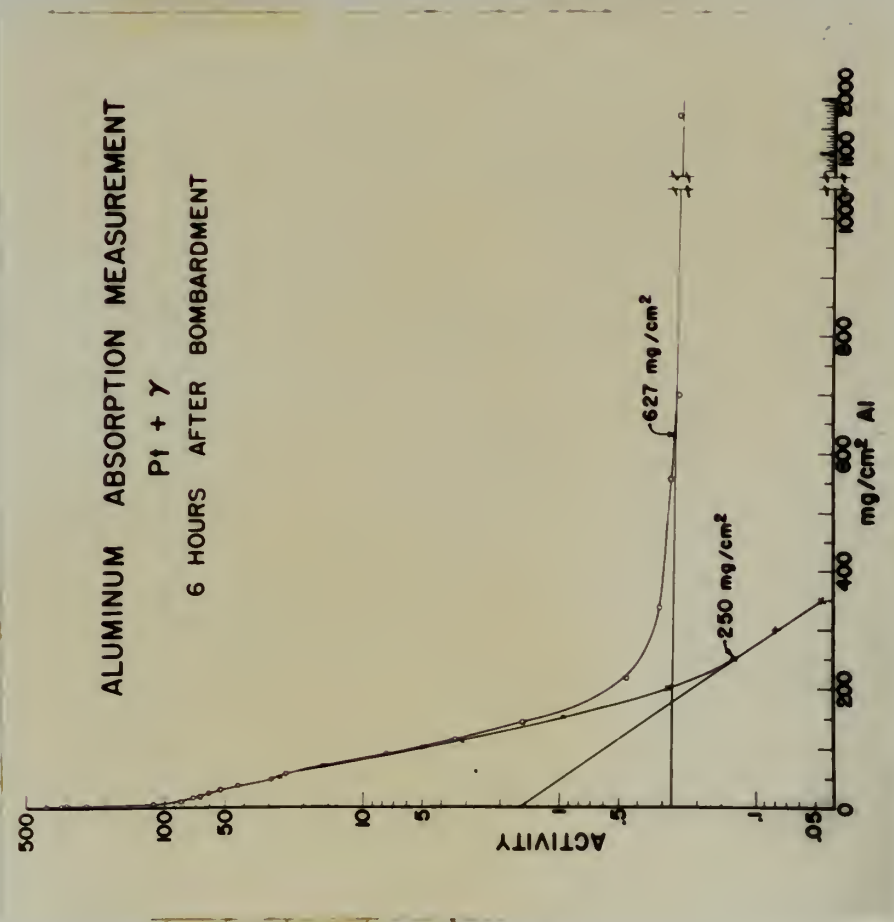
ALUMINUM ABSORPTION MEASUREMENT
Pt + γ
6 HOURS AFTER BOMBARDMENT
ACTIVITY
500
100
50
10
5
1
.5
.1
.05
627 mg/cm²
250 mg/cm²
0
200
400
600
800
1000
1200
2000
mg/cm² Al

Figure No. 17

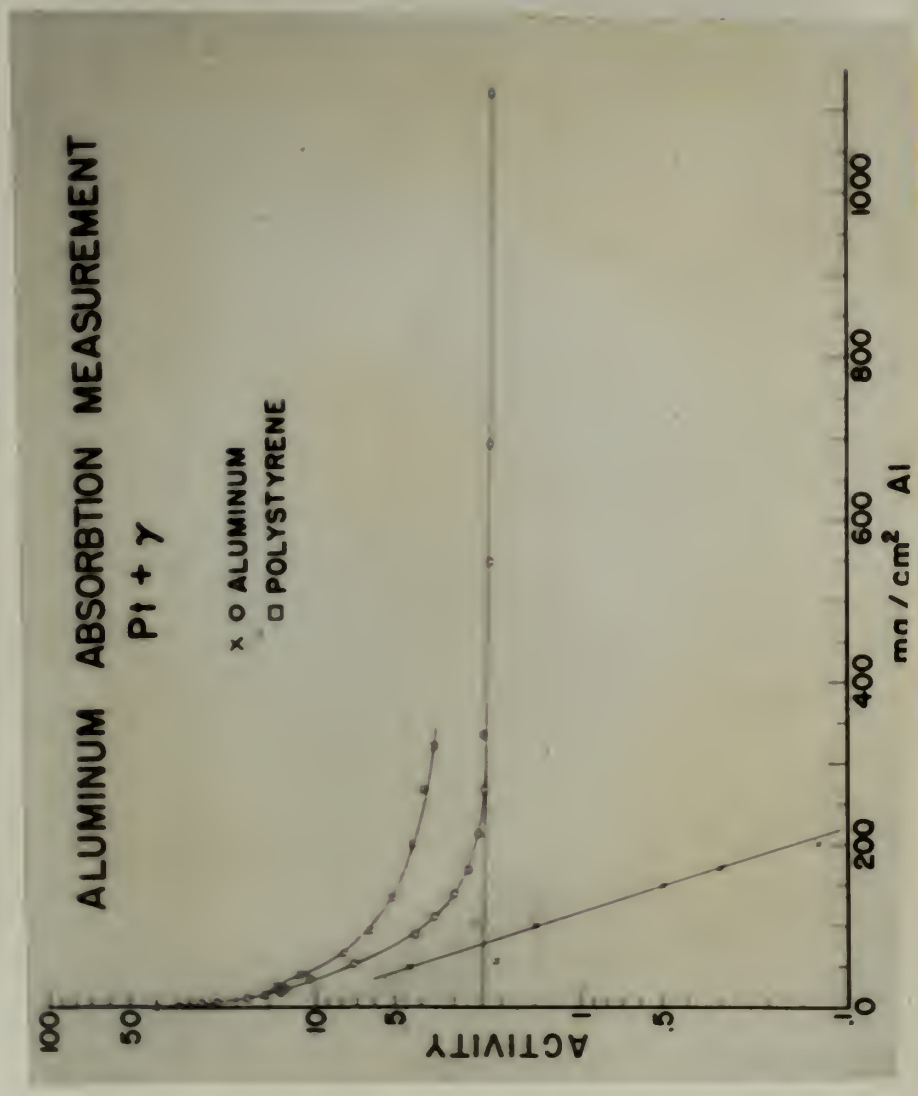
ALUMINUM ABSORBTION MEASUREMENT
Pt + γ
× ○ ALUMINUM
□ POLYSTYRENE
ACTIVITY
100
50
10
5
1
.5
.1
0
200
400
600
800
1000
mg / cm² Al

Figure No. 18

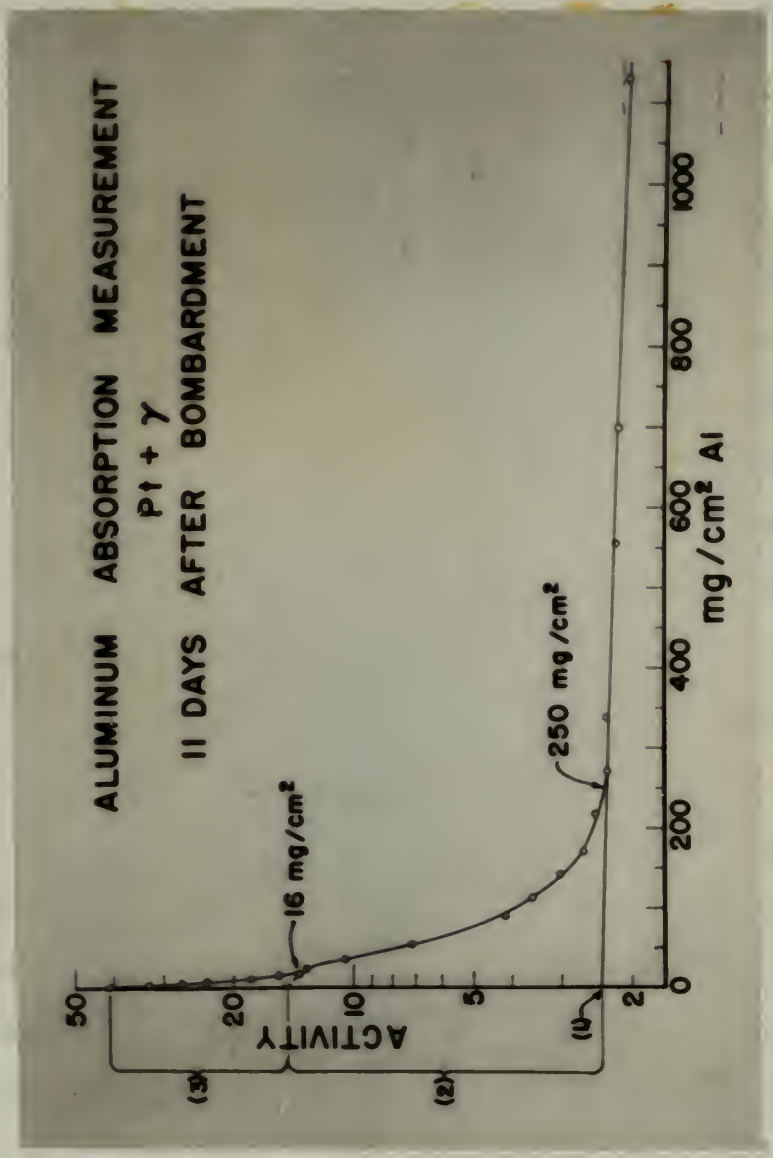
ALUMINUM ABSORPTION MEASUREMENT
Pt + γ
11 DAYS AFTER BOMBARDMENT
16 mg/cm²
250 mg/cm²
ACTIVITY
50
20
10
5
2
(1)
(2)
(3)
0
200
400
600
800
1000
mg/cm² Al

Figure No. 13

The values (1), (2), and (3) being plotted represent:

(1) strong electromagnetic activity.

(2) activity due to

(a) weak electromagnetic activity

(b) 0.265 Mev beta with 19.5 hour activity

(c) 0.32 Mev electron and a 0.45 Mev electron, both decaying with the present long period.

(3) .114 Mev electron with 4.033 day period

A series of aluminum absorptions run on the beta tube during the present long period show the following:

Days after bombardment	Electron end points
34	.114, .315, .45 Mev (fig.20)
43	.315, .45 Mev
45	.315, .45 Mev

The .315 and .45 Mev electrons appear to be decaying together. Au^{195} is an A isotope and decays by emitting a .32 Mev beta.

As in the case of the platinum foil above, the presence of X or gamma radiation was shown by making both aluminum and polystyrene absorption measurements ten days after bombardment. Lead absorptions run during this same period show that electromagnetic radiations of 0.065 or 0.116 Mev exist (fig.21). The absorption edge for lead in this region makes it uncertain which of these two values is the correct one. The 0.065 Mev value would fall within the iridium K x-ray range(0.063 to 0.075 Mev).

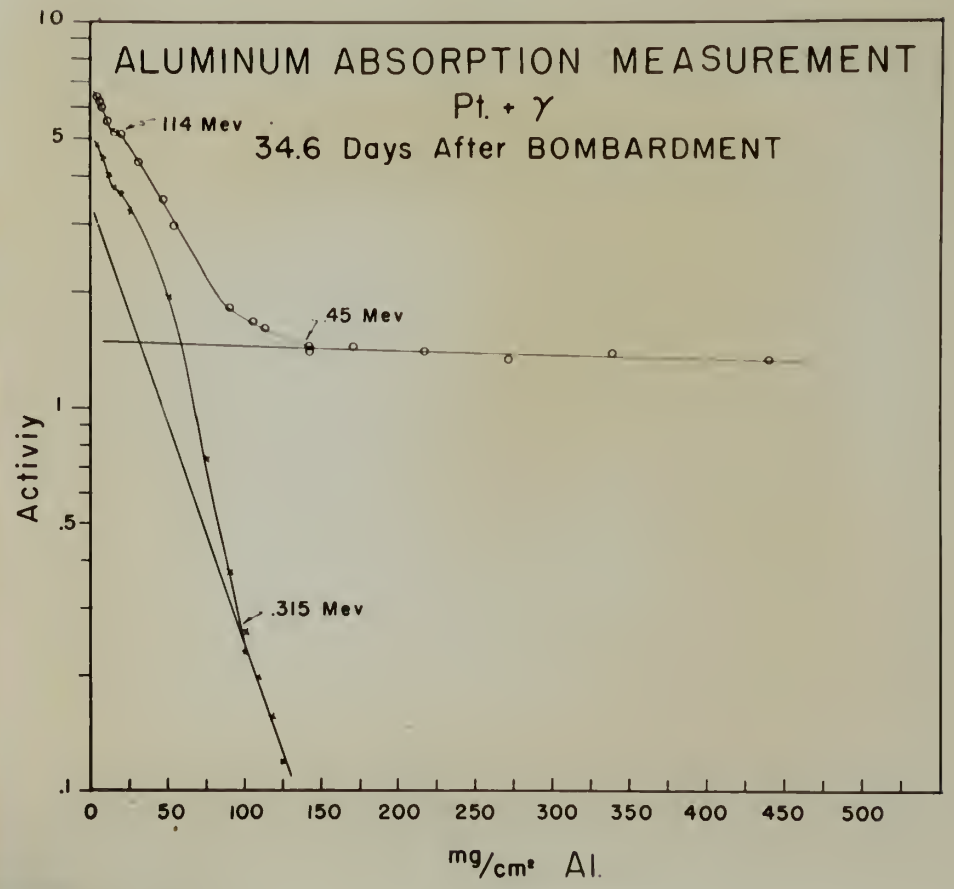
ALUMINUM ABSORPTION MEASUREMENT
Pt. + γ
34.6 Days After BOMBARDMENT
114 Mev
.45 Mev
.315 Mev
Activiy
10
5
1
.5
.1
0
50
100
150
200
250
300
350
400
450
500
mg/cm² Al.

FIGURE No. 20

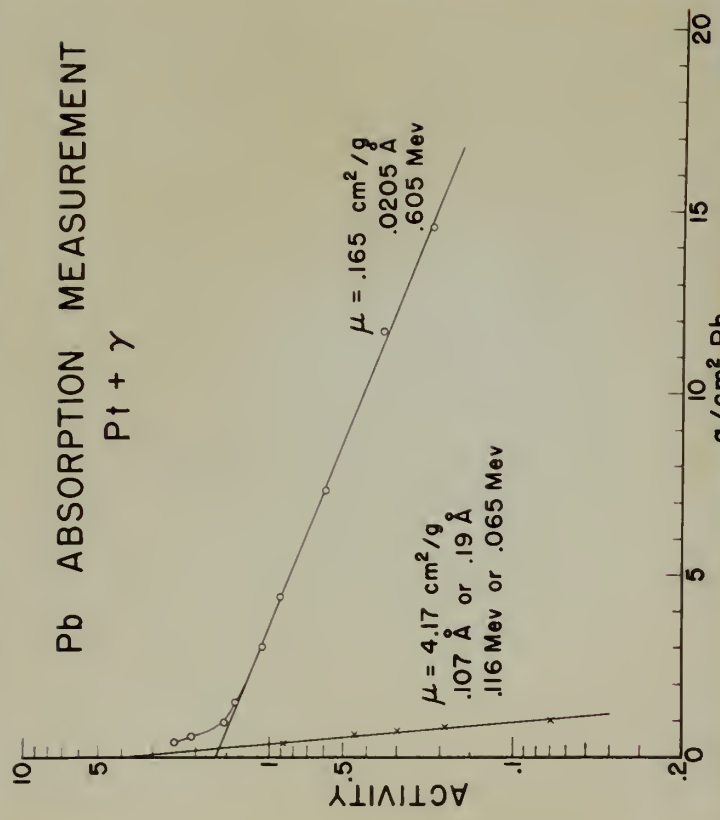
Pb ABSORPTION MEASUREMENT
Pt + γ
μ = .165 cm²/g
.0205 Å
.605 Mev
μ = 4.17 cm²/g
.107 Å or .19 Å
.116 Mev or .065 Mev
ACTIVITY
10
5
1
.5
.1
.2
0
5
10
15
20
g/cm² Pb

Figure No. 21

However an absorption measurement made with copper (fig.16) shows that the higher energy is present. Since absorption measurements from an iridium plus proton bombardment show K x-rays, it is probable that in this case the K x-rays are blanketed by the gamma energies with the four day and the longer periods and by the .45 Mev electron which is still present.

An absorption with aluminum through 258.5 mg/cm^2 polystyrene(enough to stop all particle radiation present at this time but not enough to stop much of the x-radiation) shows that electromagnetic radiation with energy corresponding to iridium L x-rays are present (fig.22). This measurement shows an energy of 0.010 Mev(1.18A) which lies within the 0.0091 to 0.0125 Mev (.99-1.36A) range of iridium L x-rays.

The results of the series of lead absorptions are tabulated below:

ENERGY	DECAY	NO. POINTS
.81 Mev	~60 minutes	2
.31 Mev	85 minutes	2
.34 Mev	~5+ days	2
1.07 Mev	4.12 days	4
.57 Mev	~81 days	2
.116 Mev	~2.0 days	3

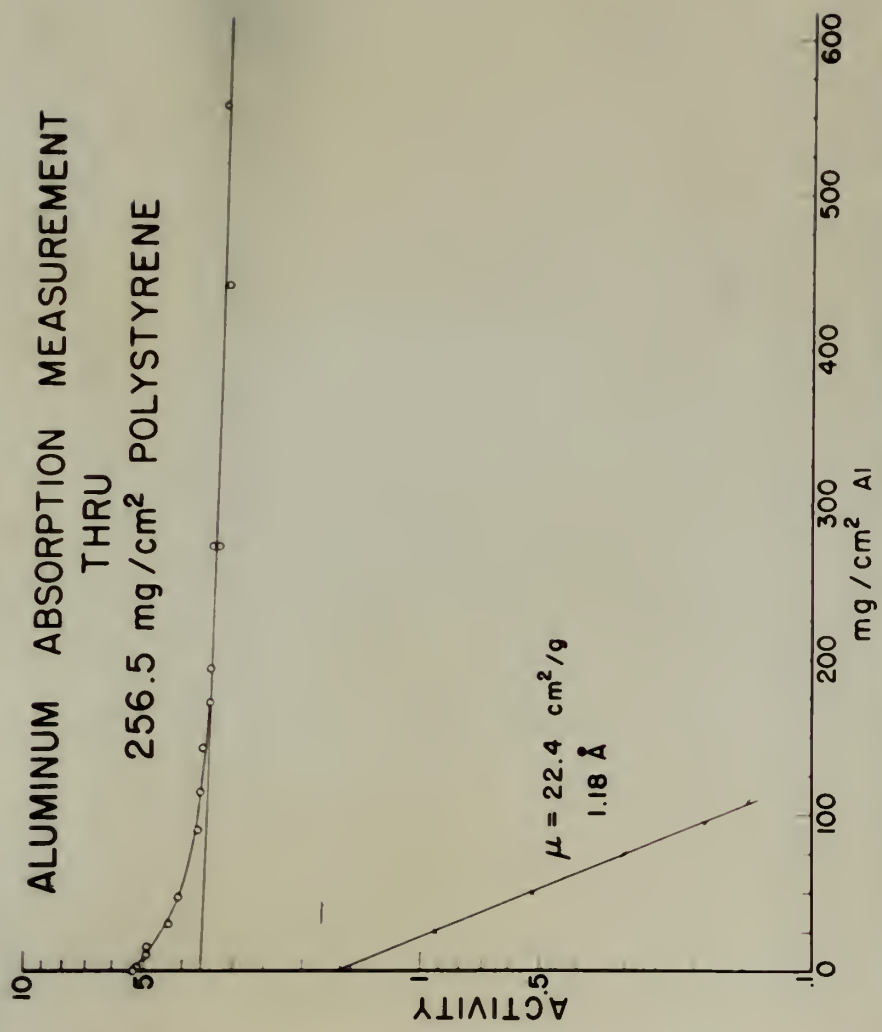
ALUMINUM ABSORPTION MEASUREMENT
THRU
256.5 mg/cm² POLYSTYRENE
μ = 22.4 cm²/g
1.18 Å
ACTIVITY
10
5
1
.5
.1
0
100
200
300
400
500
600
mg/cm² Al

Figure No. 22

Copper absorptions were run through polystyrene during the long period to identify gamma energies with Au^{199}; however the results have been very inconclusive. The heavy gamma radiation, apparently the .57 Mev found with the lead absorptions, blankets out all the weaker energies.

C. Fast neutron bombardment of mercury.

A six hour bombardment was made on mercuric-oxide with fast neutrons obtained from a lithium plus deuteron reaction. A chemical separation was performed and decay measurements were made on all fractions and on a small portion of the unseparated sample.

In the chemical separation the HgO was dissolved in 6 N.HCl. Gold and platinum carriers were added. The gold was extracted as $AuCl_4$ with ethyl acetate, was washed with 6 N.HCl and evaporated. 2 N.HCl was added and after bringing to a boil a saturated solution of SO_2 in water was added. The gold was precipitated, filtered, and plated. The mercury was precipitated as Hg_2Cl_2 by adding $SnCl_2$ in 2 N.HCl. The Hg_2Cl_2 was filtered, washed and plated. The excess of $SnCl_2$ reduced the platinum so that it could be extracted with ethyl acetate. The residue, after washing the ethyl acetate with 6 N.HCl and evaporating, was taken up with 2N.HCl and precipitated with magnesium. The washings were evaporated in a watch glass.

Decay measurements made on the various fractions have been completed and indicate the periods shown.

Mercury fraction

48 Days	Hg^{203}
2.79 Days	Hg^{197}
22 Hours	Hg^{197}
30 Minutes	Hg^{199} and Hg^{205}

Gold fraction

2.83 Days	Au^{198} or Au^{199}
50 Minutes	Au^{200}

Platinum fraction (fig.23)

82 Days

4.08 Days

24 Hours

75 Minutes

The residue and the unseparated portion gave a very complex curve that could not be broken down.

Aluminum absorptions run on the unseparated fraction indicate electron end points at 18 mg/cm^2, 250 mg/cm^2 and 640 mg/cm^2.

D. Other Bombardments.

A one hour osmium plus alpha bombardment was made and the products were separated chemically. The platinum fraction gave an activity of only one count per second. No definite results were obtained as to the period of this activity. It is planned to repeat this experiment

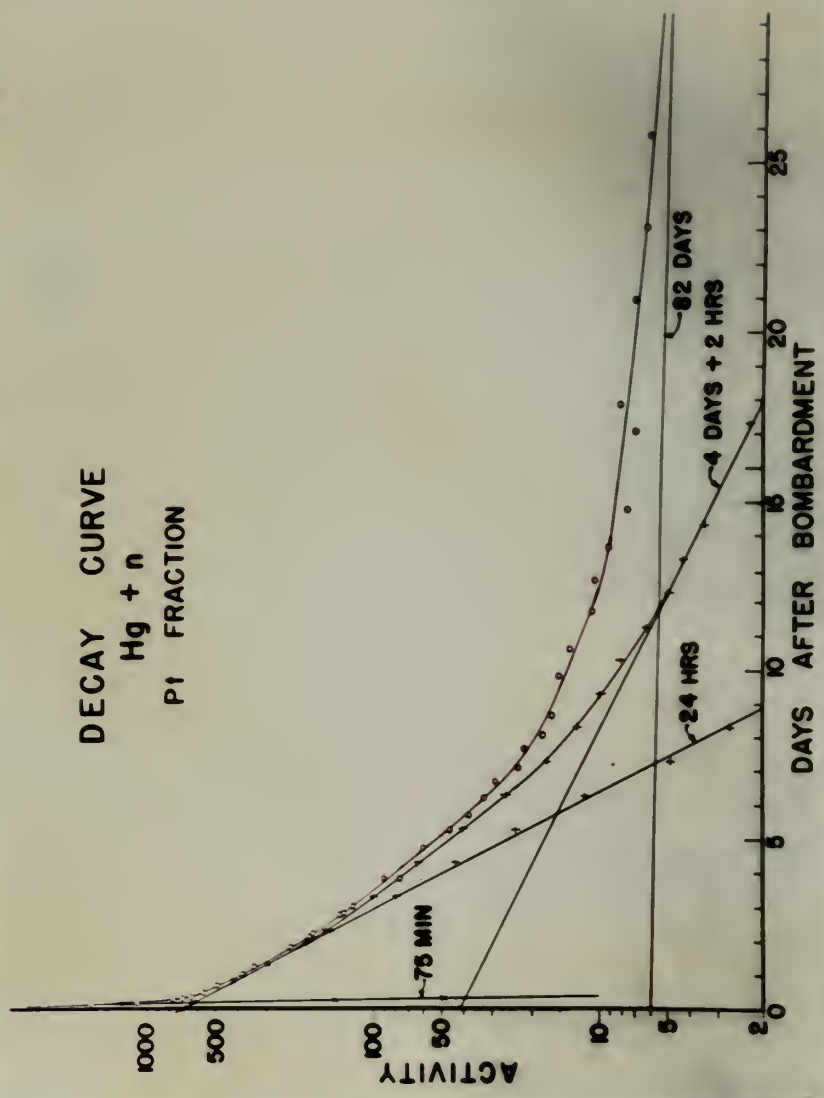
DECAY CURVE
Hg + n
P1 FRACTION
ACTIVITY
1000
500
100
50
10
5
2
75 MIN
24 HRS
4 DAYS + 2 HRS
82 DAYS
0
5
10
15
20
25
DAYS AFTER BOMBARDMENT

Figure No. 23

using a greater quantity of osmium.

A one hour gold plus 17.5 Mev gamma bombardment was made. There was no activity in the platinum fraction. As the chemical separation took but one hour, and shortest period expected in the platinum fraction was 75 minutes, it is believed that the experiment was conclusive.

In order to aid in locating the 75 minute and 19.5 hour period a gold plus fast neutron bombardment and an iridium plus slow neutron bombardment will be made. In the iridium neutron bombardment a considerable activity from Ir^{194} is expected. Ir^{194} decays by beta emission. If platinum is separated periodically and if an activity is present it can be assigned to Pt^{194}.

SUMMARY AND CONCLUSIONS

A. Platinum 191

Half-life	2.0 days
Method of decay	K capture
Gamma energies	0.59 Mev 1.75 Mev
Electrons	0.49 Mev

A 2.0 day period was obtained both from proton bombardments of iridium and gamma bombardments of platinum. Since the two stable isotopes of iridium have mass numbers of 191 and 193, an iridium proton neutron reaction should give platinum isotopes of the same two mass numbers. Since there is considerable evidence to indicate that the 4.08 day period should be assigned the mass number 193 (see Platinum 193 below), the 2.0 day period would then go with the mass number 191. The two day period is not isomeric with Pt^{193} since if this were the case, the amount of the two day half-life formed in a platinum plus 17.5 Mev gamma neutron reaction should be comparable with the amount of the 4 day half-life formed. If the two day period were formed by an iridium proton gamma reaction making it an isomer with a stable platinum isotope of mass numbers 192 or 194 there should eventually be in the platinum fraction some evidence of the unstable iridium isotope of the same mass number formed

by the K capture decay of the 2.0 day period. This is not the case.

Because of the small abundance of platinum 192 (0.78%) as compared with that of 194 it would be expected that the amount of 191 formed from a platinum gamma neutron reaction would be very small as compared with the amount of 193 formed. This is verified by the fact that in the one hour platinum gamma bombardment there is no discernable two day period while in the six hour bombardment the two day period is apparent only with a low activity.

The 2.0 day half-life compares with a 3.00 day half-life previously reported in the literature for platinum 191 (ref.1). Other investigators have reported obtaining this isotope from an iridium deuteron two neutron reaction and from a platinum neutron two neutron reaction. (ref.1). This isotope has not previously been obtained by the two methods reported here.

Platinum 191 decays by K capture. Both L and K x-rays have been measured. Lead and silver absorptions give approximately a 0.067 Mev electromagnetic radiation which decays with a two day half-life. This is an intermediate energy of iridium K x-rays, and agrees with results obtained by previous investigators (ref.1). Aluminum absorption measurements show electromagnetic energies of 0.010 Mev and 0.014 Mev that decay with this period. The 0.010 Mev is an intermediate energy of iridium L x-rays.

The lead absorptions also show a 0.59 Mev gamma energy decaying at a two day half-life. This is in fair agreement with the 0.57 Mev gamma energy previously reported for this isotope. A 1.45 Mev electron decaying with the two day period is apparent from aluminum absorptions. It occurs with a low frequency and is probably a Compton electron, and would indicate a 1.75 Mev gamma energy. This did not appear in lead absorptions, however Wilkinson (ref. 1) reports a hard gamma of about 1.5 Mev.

The 0.49 Mev electron which decays at a two day half-life from the aluminum absorption measurements is probably an internal conversion electron going with the gamma measured at 0.59 Mev.

B. Platinum 193

Half-life	4.08 days
Method of decay	K capture
Gamma energies	.116 Mev
	0.35 Mev
	1.07 Mev
Electron energies	0.114 Mev

The 4.08 day half-life was obtained from proton bombardments of iridium, 17.5 Mev gamma bombardments of platinum, and fast neutron bombardments of mercury. The platinum 193 position is the only one that could possibly be arrived at from both an iridium plus proton reaction and a mercury plus fast neutron reaction. Thus there could be slight doubt that the 4.08 day period is correctly located.

This half-life compares with 4.33 and 3.5 day half-lives reported for this isotope by previous investigators. The three reactions listed above to obtain platinum 193 have not been reported in the literature. This isotope has been previously obtained by the following reactions (ref. 1, 2, 11):

platinum-neutron-gamma

platinum-neutron-two neutron

platinum-deuteron-proton

iridium-deuteron-two neutron

iridium-alpha-proton two neutron

Lead absorptions gave a 0.55 Mev gamma and a 1.07 Mev gamma which decay at a four day rate. These energies have not previously been reported. An electromagnetic radiation which could be either 0.118 Mev or 0.085 Mev also shows up. Silver and copper absorption measurements show that both of these energies are actually present. The 0.085 Mev energy corresponds to the K x-ray of iridium indicating decay by K capture. This agrees with the method of decay previously reported in the literature (ref.1,2). Aluminum absorptions through polystyrene give an electromagnetic energy of 10 Kev corresponding to the L x-ray of iridium. Aluminum absorptions also gave a 0.114 Mev beta energy decaying at a 4.02 day half-life. This is intermediate between the 0.112 Mev and the 0.115 Mev values previously reported. The 1.5 Mev gamma reported by Wilkinson (ref.1) was not observed.

C. Platinum 195

Half-life	75 minutes
Method of decay	Gamma or possibly beta
Gamma energies	0.31 Mev
Electron energies	1.42 Mev.

The 75 minute half-life was obtained from 17.5 Mev gamma bombardments of platinum and from fast neutron bombardments of mercury. This activity had previously been reported by both of these reactions(ref. 5,11). However the previous work done on this isotope was incomplete and inconclusive. This activity has also been reported as having been obtained by platinum deuteron proton and platinum fast neutron reactions. Half-lives of 60 minutes, 78 minutes and 87 minutes have been reported by the above methods in the literature (ref 3, 4, 5, 11).

Lead absorption measurements gave a gamma energy of 0.31 Mev which decayed at approximately a 75 minute half-life. This compares with the 0.337 Mev gamma reported in the literature. Aluminum absorption measurements give an electron of 1.42 Mev attributable to this activity. This has not been reported previously. The 280 Kev and 323 Kev internal conversion electrons reported by Hole (ref. 11) were not detected.

The mass number and the form of decay of the isotope decaying with this half-life is still in doubt.

D. Platinum 197

Half-life	19.5 hours
Method of decay	Beta
Gamma energies	None detected
Electron energies	0.68 Mev

The 20 hour half-life was obtained by gamma platinum gamma and mercury fast neutron reactions, both of which are reported in the literature (ref 5, 10). In each case however the work done on this activity was very sketchy. This activity was also reported by the following reactions (ref 6, 7, 8): platinum deuteron proton, platinum neutron two neutron, and platinum neutron gamma. The 19.5 hour half-life is somewhat greater than the 17.5 and 19 hour figures reported in the literature.

Aluminum absorption measurements show a 0.68 Mev beta energy which decays with a 20 hour half-life. This compares with the 0.65, 0.72, and 0.54 Mev values previously reported. The 0.50 Mev gamma energy reported in the literature was not detected.

E. Platinum 199

Half-life	82 days
Method of decay	Beta
Gamma energies	0.57 Mev
Electron energies	0.45 Mev

The 82 day half-life was obtained by a mercury fast neutron alpha reaction and by a platinum gamma reaction. However it is believed that in the latter case the 82 day period is produced by the neutron flux present rather than by the gamma. This period was previously reported only by a platinum slow neutron reaction (ref 8). The mass number to which this activity belongs is not well fixed however aluminum absorption measurements give beta energies of .49 and .315 Mev decaying with a half-life of about 81 days. Lead absorption measurements give a gamma energy of 0.57 Mev which decays with a half-life of 81 days. Neither the 0.05, and 0.21 Mev gammas assigned to Au^{199}, or the .15 and .37 Mev gammas assigned to Hg^{199} were detected with certainty. A 0.32 Mev beta is assigned to Au^{199}. This is evidence that Pt^{199} decays into Au^{199}.

BIBLIOGRAPHY

1. Physical Review 75, 1019, Wilkinson.
2. Physical Review 74, 601, Mandeville, Scharb, Keighton.
3. Physical Review 74, 1536, Mack, Waddel, Fagg, Tobin.
4. Physical Review 73, 479, Duckworth.
5. Physical Review 60, 473, Sherr, Bainbridge, Anderson.
6. Physical Review 77, 845, Cork.
7. Physical Review 52, 375, McMillan, Karmen, Buben.
8. Proc Camb Phil Soc. 37, 422, Krishnan, Nahum.
9. Proc Roy Soc A 190, 321 and 333
10. Helvetica Physica Acta 21, 200, Waffler, Hirzel.
11. Arkiv Mat Astron Fysik 36A, 49, Hole.
12. Bulletin of the American Physical Society 27, 27, J.M. Cork.
13. Helvetica Physica Acta 24, 529.

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We submit this paper with a feeling of gratitude toward those we have worked with.

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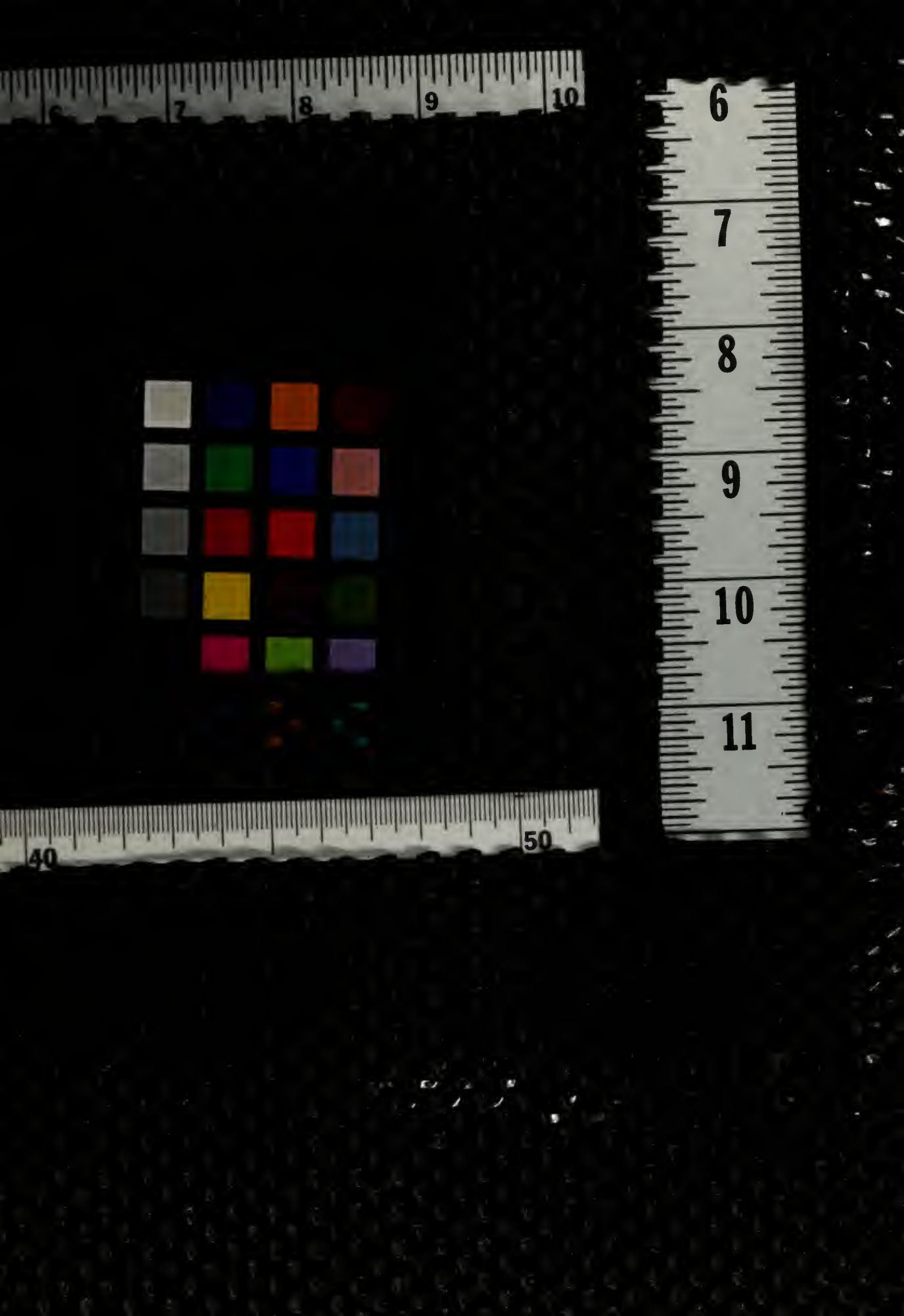

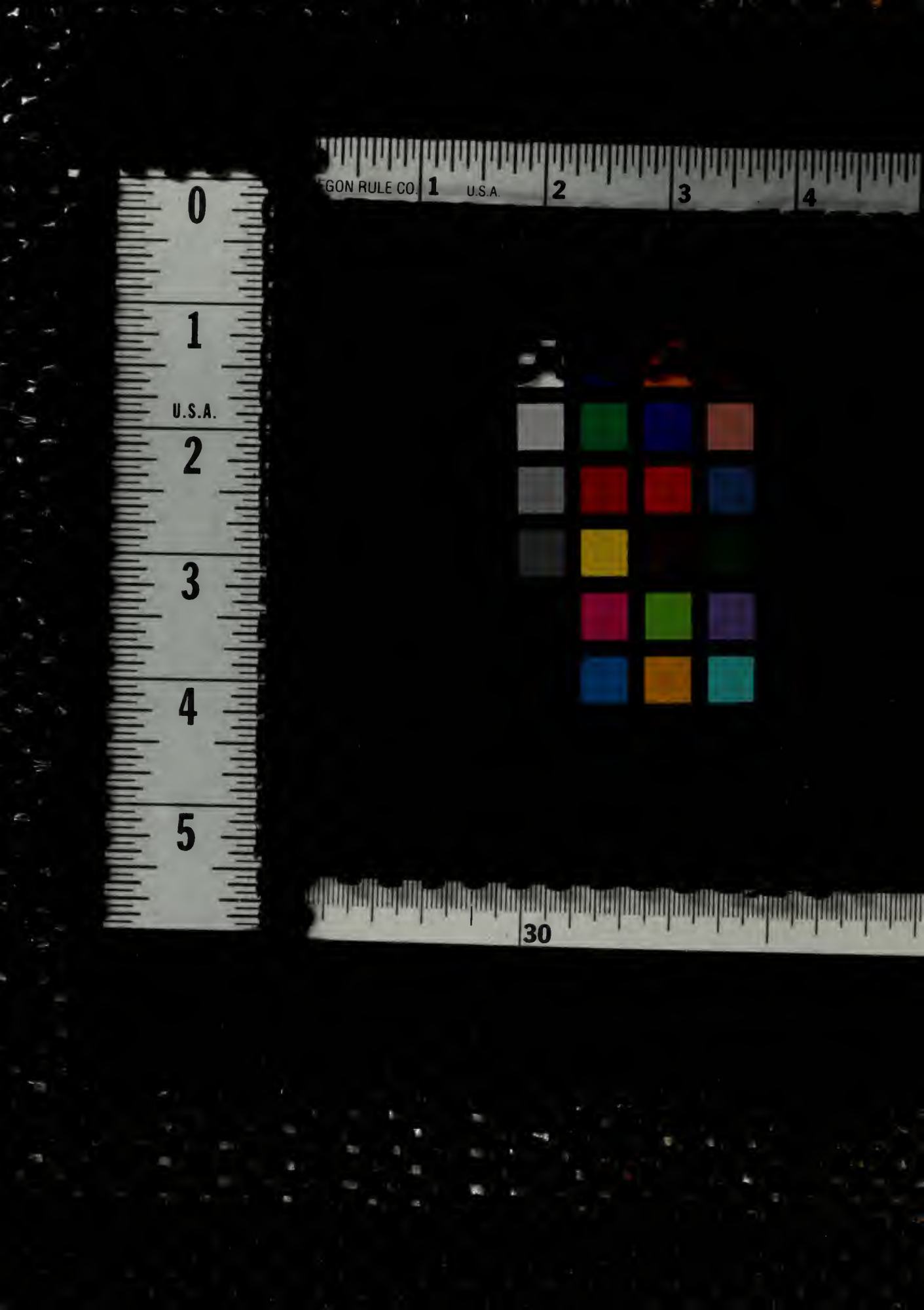
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